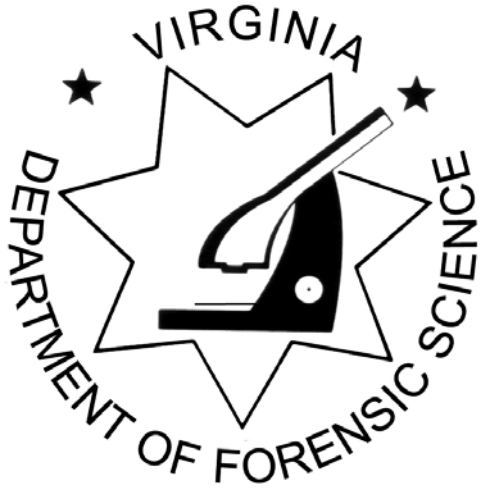
DEPARTMENT OF FORENSIC SCIENCE



BREATH ALCOHOL SECTION

BREATH TEST OPERATOR INSTRUCTIONAL MANUAL

INTOXILYZER MODEL 5000

Revised September 2005

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ALCOHOL

Effective July 1, 2005 the Division of Forensic Science of the Department of Criminal Justice Services became the Department of Forensic Science. Any reference herein to this agency prior to July 1, 2005 shall be construed to mean the Division of Forensic Science and, on or after July 1, 2005, shall be construed to mean the Department of Forensic Science.

INTRODUCTION

The Division of Consolidated Laboratory Services, Bureau of Forensic Science, deriving its authority from §l8.2-267 and §18.2-268 of the Code of Virginia, was responsible for the administration of the Virginia Breath Test Program from the program's inception in 1972 until 1990. On July 1, 1990 the Bureau of Forensic Science became the Division of Forensic Science, and the Division of Forensic Science became the Department of Forensic Science (DFS) on July 1, 2005. The Department's Breath Alcohol Section ensures that statewide quality assurance and operational standards are followed by the Commonwealth's law enforcement agencies when administering breath tests. To accomplish its goals, the Department of Forensic Science provides training, equipment, supplies, and laboratory support to local, state, and federal authorities. In addition to its responsibility for training and licensing operators, the Department certifies all evidential breath test instruments at least once every six months.

From a modest but enthusiastic beginning, the program has experienced steady growth with expansion in the number of licensed operators and the number of breath tests conducted. Currently there are over 4,500 officers who are authorized by the Department to conduct breath tests in Virginia. From an initial ~13,500 tests in 1973, the first full year of operation, there has been an almost three-fold increase in the number of breath tests administered annually.

The rules and regulations that are promulgated by the Department establish specific requirements for administering breath tests. Only those individuals who have been trained and licensed by the Department of Forensic Science may conduct breath tests; furthermore, these tests must be administered only in the prescribed manner and only on approved and certified instruments.

To accomplish the task of training, the Department of Forensic Science supplements its staff by using police instructors to assist during the initial certification course. All police instructors must successfully complete a Breath Alcohol Instructor Course sponsored by the Department in addition to an initial certification course. The Department and the Breath Alcohol Section staff are extremely grateful to these professional volunteer instructors for their dedicated service to the program.

Working together, the Department of Forensic Science and the Commonwealth's law enforcement community make the difference in providing a Breath Alcohol Section that is an effective tool in making Virginia's highways a safer place to drive.

Any licensed operator trained using a previous version of the Department's Intoxilyzer 5000 manual is still a valid operator. However, information contained herein supersedes that in previous manuals.

The Breath Alcohol Section of the Department of Forensic Science encourages inquiries.

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Website: www.dfs.virginia.gov

TYPES OF BREATH TEST EQUIPMENT

The continuing problem of the drinking driver has necessitated the advancement of detection and testing devices for alcohol since the early years of the automobile. Breath, because of the noninvasive nature of obtaining a sample, has been an obvious medium for which testing methods have been developed.

Breath testing equipment can be categorized into two types as described below:

Non-evidential Test Devices

Non-evidential test devices are portable devices used primarily in the field. These are electrochemical solid-state devices with pass/fail indicator lights or a digital readout. These devices are commonly called Preliminary Breath Test devices or PBTs.

Some examples: Alcosensor III, Alcosensor IV, CMI SD-2 and CMI SD-5.

Evidential Test Devices

Evidential test devices give a quantitative analysis of alcohol in the breath and blood. One instrument, the Intoxilyzer 5000, is used by law enforcement personnel in Virginia. The Intoxilyzer 5000 is listed on the National Highway Traffic Safety Administration's (NHTSA) Conforming Products List as the Intoxilyzer 5000CD/FG5.

> **Infrared Device.** This device collects a sample of breath through which an infrared light beam is passed. A detector in the device measures the amount of alcohol in the sample by measuring the amount of light the alcohol absorbs. The results are printed and/or obtained directly from a digital readout.

NOTES

INSTRUMENTATION

Intoxilyzer Model 5000

The operator should be familiar with the parts of the instrument in order to follow the checklists and discussions concerning the operational features. The following pages identify and describe these parts.

Parts, Controls, and Indicators: Pictures of the instrument are shown in Figures 1, 2 and 3.

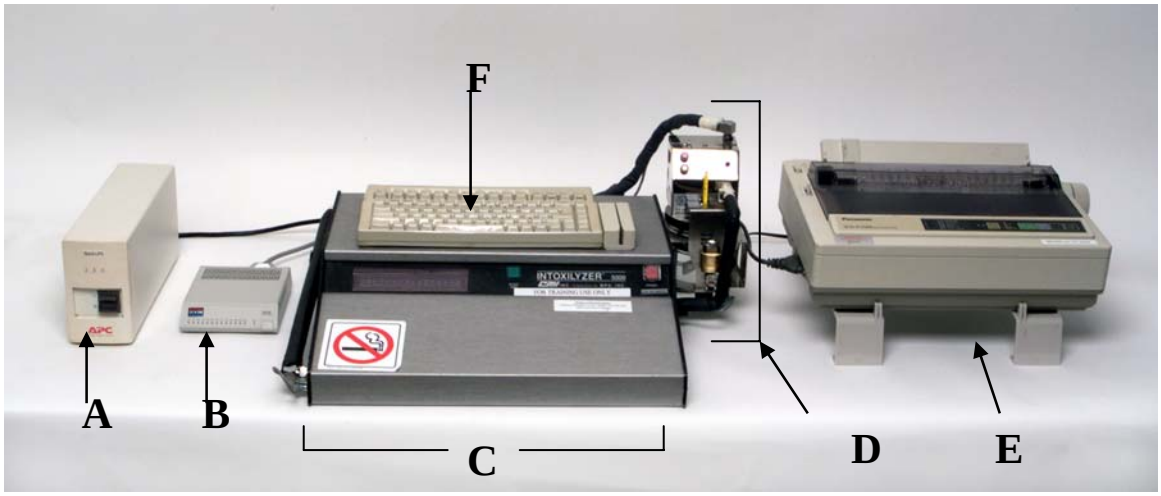

Figure 1

A: Battery Back-Up (also called an uninterruptible power supply)
B: Modem
C: Intoxilyzer 5000
D: Guth 34C Simulator
E: Printer
F: Keyboard with Card Reader

Front View

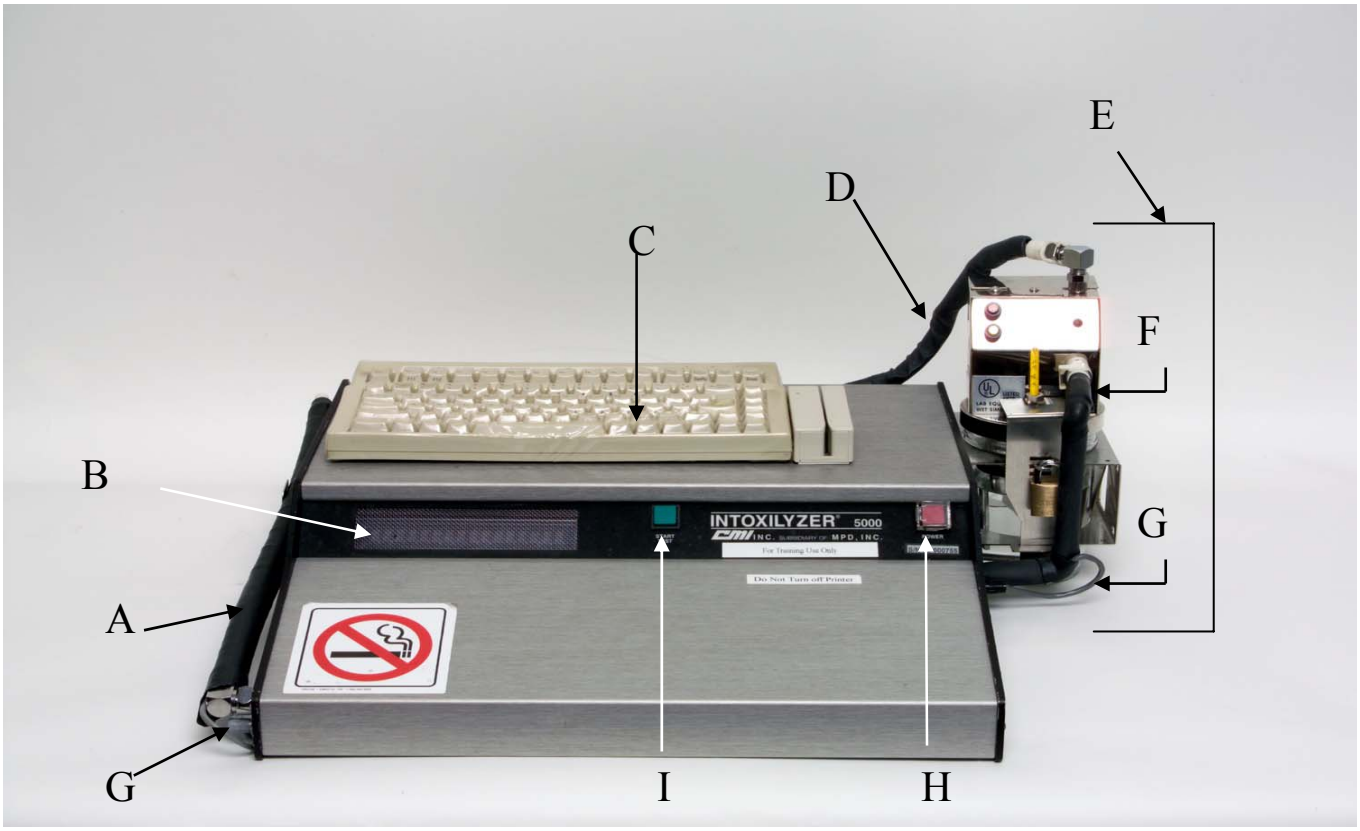

Figure 2

A: Breath Tube
B: Digital Display
C: Keyboard with Card Reader
D: Simulator Vapor Return Hose
E: Guth 34C Simulator
F: Simulator Vapor Hose
G: Hose Heater Connectors
H: Power Button
I: Start Test Button

Breath Tube		A heated, reinforced plastic tube through which the subject blows into the sample chamber. The breath tube also contains the RFI (Radio Frequency Interference) antenna.
Digital Display		A sixteen character alphanumeric read-out that relates which operation the instrument is performing, alerts the operator to required actions, and expresses results of alcohol tests in grams per 210 liters of breath.
Keyboard		Used to enter information into the instrument. Additional information can be obtained from specific function keys.
	F1	Prints a copy of the Certificate of Analysis from the last test as long as another test has not been started.
	F2	Displays the information and results from the last test.
	F3	Used when executing the Monthly Maintenance/Simulator Solution Change Checklist.
	F5	Resets the instrument back to scrolling DFS, TIME, DATE.
	F7	Runs a 10 second Air Blank.
	F9	Simulator ON/OFF. Turns the power to the simulator on and off.
	F10	Displays the current certification date of the instrument.
Mouthpiece		A disposable, clear plastic trap (not pictured) which fits in the end of the breath tube. It has two functions: (1) to accept the subject's breath and (2) to prevent unwanted substances such as spit or vomit from entering the instrument. Use only one mouthpiece per subject.
Simulator Return Hose		Returns the simulator air/alcohol sample to the simulator from the instrument.
Simulator Vapor Hose		Carries the simulator air/alcohol sample to the instrument from the simulator.
Hose Heater Connectors		The breath tube, simulator vapor hose, and simulator vapor return hose have heaters that are attached to the instrument through these connectors. These connectors heat the hoses to keep condensation from forming in the system.
Power Button		A red button used to apply AC power to the instrument. DO NOT turn off the instrument without prior approval of DFS.
Start Test Button		A green button used to initiate a test.

Rear View

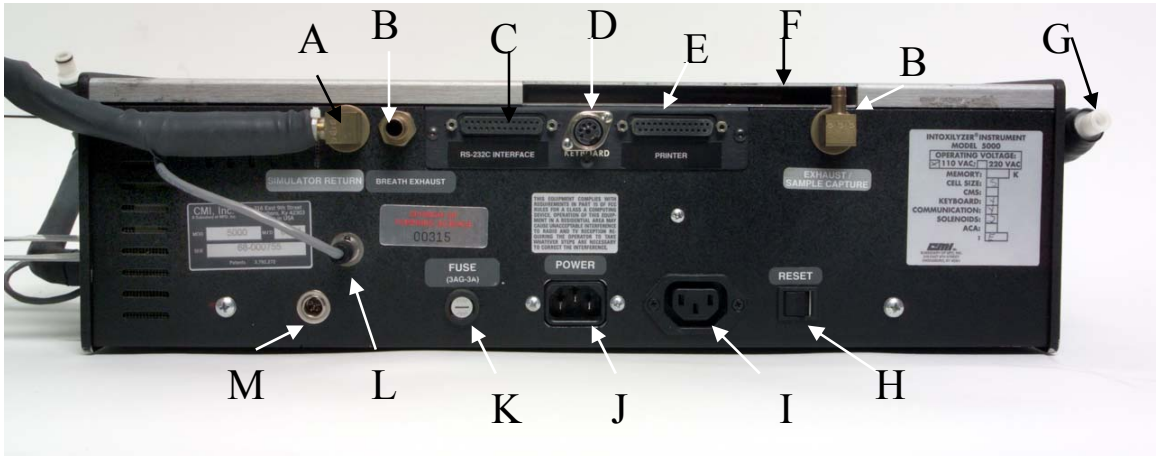

Figure 3

A: Simulator Return Port
B: Exhaust Ports
C: Modem Connector
D: Keyboard Connector
E: Printer Connector
F: Fan Vent
G: Breath Tube
H: Reset Switch
I: Simulator Power Jack
J: Power Jack
K: Fuse
L: Hose Heater Connector
M: Simulator Temperature Probe Connector

Simulator Return Port	This port is used for recirculation of the external simulator samples. A heated SIMULATOR VAPOR RETURN hose connects the simulator to this port on the instrument.
Exhaust Ports	The breath sample and room air blanks are exhausted from these ports.
Modem Connector	This 25 pin connector is used to connect the instrument to a computer modem for data communications.
Keyboard Connector	The instrument keyboard plugs into this DIN socket.
Printer Connector	A standard CENTRONICS interface cable is used to connect the instrument to an external printer through this socket.
Reset Switch	This rocker switch is activated only in isolated circumstances to cancel all operations and return the instrument to the scrolling mode. DO NOT activate this reset switch without prior approval by DFS.
Simulator Power Jack	The simulator power cord is plugged into this receptacle.
Power Jack	The power cord is plugged into this receptacle.
Fuse	The instrument's main fuse is behind this cover. DO NOT replace the fuse without prior approval of DFS.
Simulator Temperature Probe Connector	The simulator temperature probe is connected to the instrument through this connector. The probe allows the instrument to electronically monitor the simulator temperature.

Guth 34C Simulator

The Guth Model 34C Simulator (Figure 4) verifies that the instrument is working correctly. The simulator is specially designed to maintain a constant temperature, which creates a standard alcohol/air mixture. The volume of the solution in the simulator is 500 ml (approximately 17 fl. oz.). The tolerance limits for the simulator results are 0.090 - 0.105 grams per 210 liters of breath. If the simulator results are higher or lower than the allowable limits, the instrument will produce an "OUT OF TOLERANCE" message. The solution is maintained within a temperature range of 33.8 to 34.2° C (approximate breath temperature). This temperature variation will not result in a significant difference of any vapor reading. The Intoxilyzer 5000 monitors the temperature of the simulator during the testing sequence. It will not take a simulator sample unless the temperature of the simulator is within range and has remained stable for a period of three minutes.

Preventive maintenance should be performed on or about the 1st of each month or before the instrument prompt indicates “SOL CHANGE FAIL”. The Intoxilyzer 5000 gives a five day warning, a four day warning, etc. before the instrument disables itself. The Intoxilyzer 5000 also gives a 10-test warning as the 150th simulator sample is approached. If a test is aborted before a simulator sample is taken, then that sample does not count as part of the 150 simulator samples, since a simulator sample was not taken. If the simulator solution is not changed prior to the 150th simulator test, the instrument will disable itself. The instrument counts the number of simulator samples and days since the simulator solution was last changed. If either of these situations occurs and the instrument is disabled, the Breath Alcohol Section of DFS must be contacted so that the instrument can be returned to service. The solution must also be changed if two consecutive OUT OF TOLERANCE instrument messages are received by an operator.

The simulator solution supplied by the Department of Forensic Science for the Intoxilyzer 5000 is premixed and meets the criteria established by the Department of Forensic Science. Each individual batch of solution is independently analyzed to confirm its concentration. These solutions are to be used only for evidential breath testing in Guth Model 34C simulators used in conjunction with an Intoxilyzer 5000.

Guth 34C Simulator

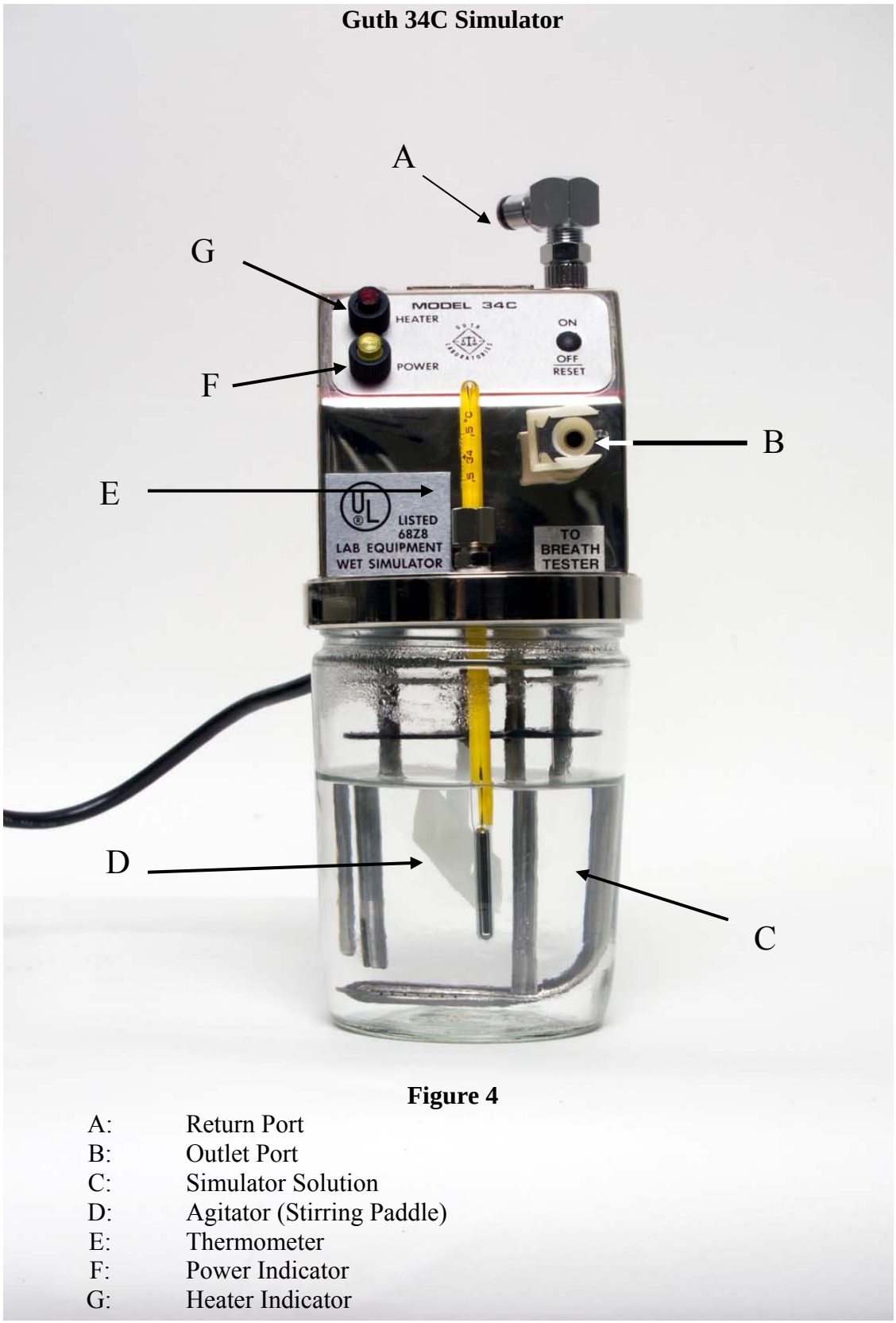

Figure 4

A: Return Port
B: Outlet Port
C: Simulator Solution
D: Agitator (Stirring Paddle)
E: Thermometer
F: Power Indicator
G: Heater Indicator

Printer

The Panasonic KX-P1150 is a 9 pin dot matrix printer. This printer can be operated entirely with the control panel buttons with the exception of loading paper. The following pages list some of the parts and operations of this printer which are shown in Figures 5 and 6.

Top Cover This is used to protect the drive mechanisms and forms. It can also be used as a form easel.

Control Panel These buttons are used to control virtually all printer operations. Refer to Figure 7.

Centronics Parallel Interface Connector This is used to connect the instrument to the printer.

Head Gap Lever This is used to vary the striking pressure of the print head. This lever should be positioned between the "D" and "G".

Paper Feed Selector THIS MUST BE LEFT IN THE DOWN POSITION (pulled toward you), as this engages the tractor drive.

Power Switch This is used to turn the power on and off. DO NOT TURN OFF THE PRINTER UNDER NORMAL CIRCUMSTANCES!

Platen Knob This is used for fine vertical adjustments of the Certificates of Blood Alcohol Analysis. **DO NOT USE UNLESS RETRIEVING MISALIGNED DOCUMENTS.**

Tractors These are used to feed the forms and to help keep them aligned in the printer.

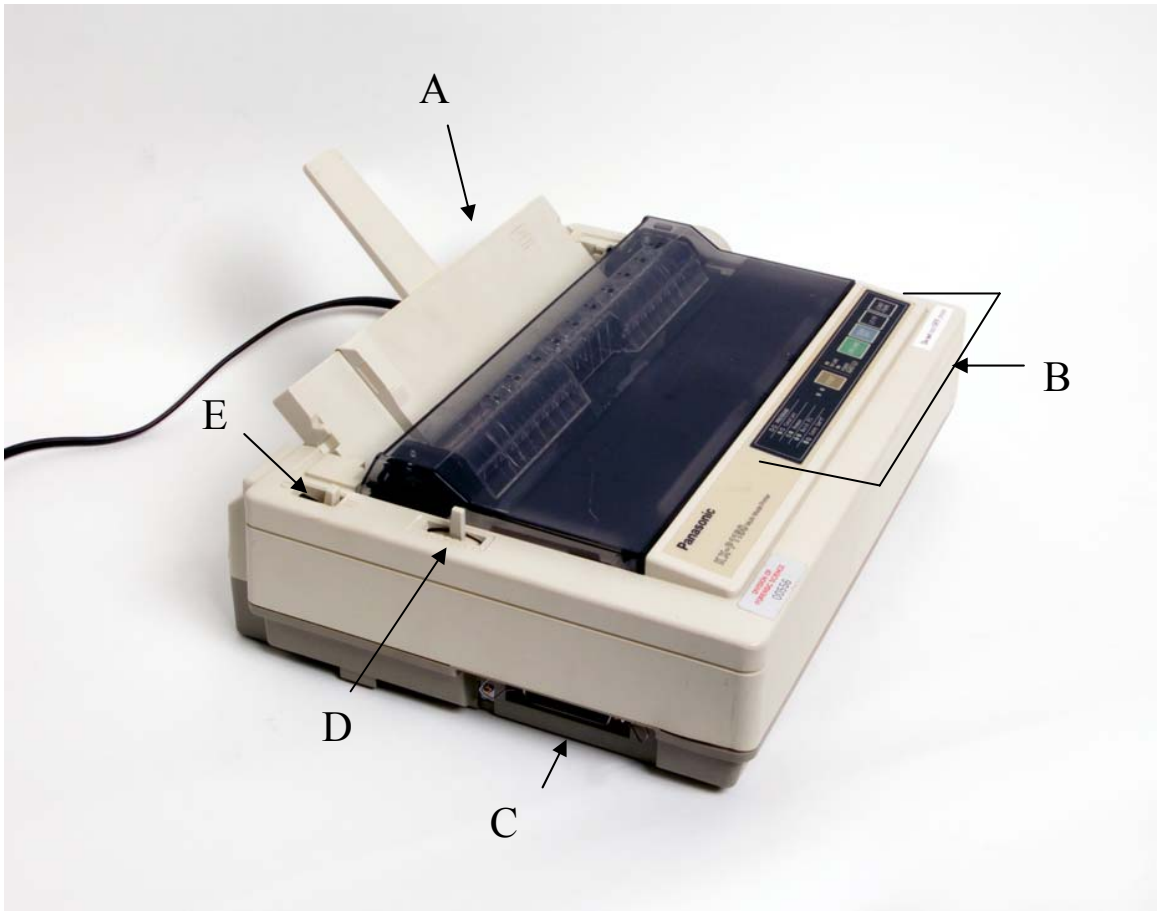

Figure 5

A: Top Cover
B: Control Panel
C: Centronics Parallel Interface Connector
D: Head Gap Lever
E: Paper Feed Selector

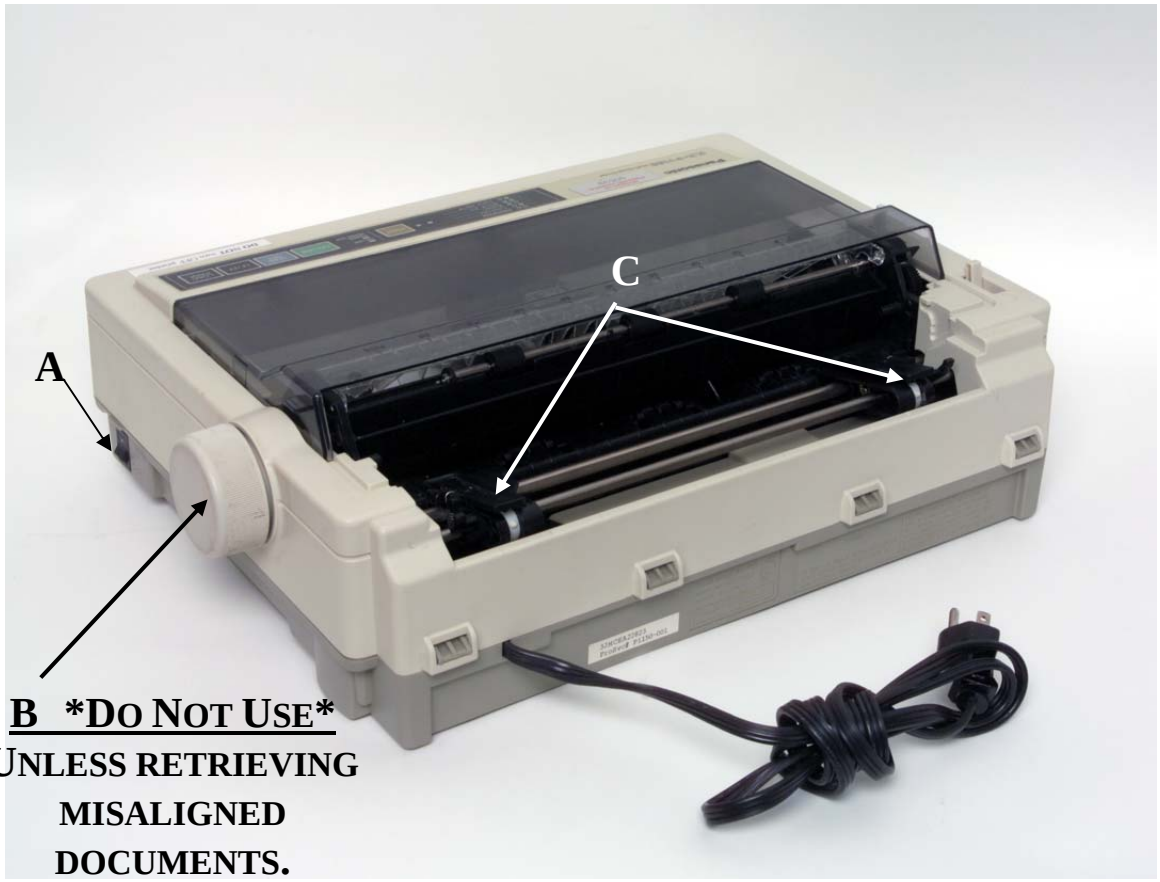

Figure 6

A: Power Switch
B: Platen Knob
C: Tractors

Printer Control Panel

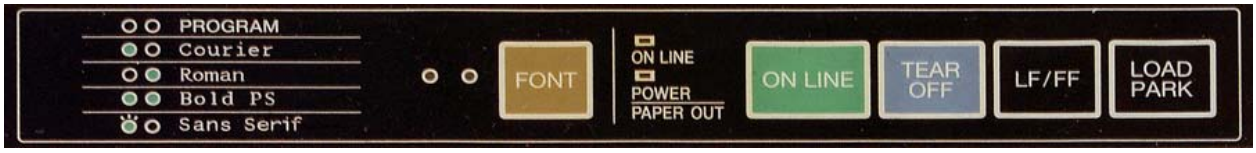

Figure 7

Font Indicators	Both indicators should be unlit which indicates the PROGRAM font is being used.
FONT Button	Each pressing of this button changes the font selected as indicated by the Font List.
ON LINE Indicator	This indicator must be lit for the printer to generate a Certificate.
POWER & PAPER OUT Indicator	This indicator must be lit (not flashing) for the printer to generate a Certificate.
ON LINE Button	This button controls the ON LINE indicator.
TEAR OFF Button	This button should be pressed after the Certificate of Blood Alcohol Analysis is printed. The Certificate will then advance so that it can be torn off.
LF/FF Button	This button should not be used when operating the Intoxilyzer 5000.
LOAD PARK Button	This button is used to load forms into the printer or to reposition misaligned forms.

Residual Mouth Alcohol and the Breath Sample Curve

Residual mouth alcohol must be considered when conducting a breath test. After drinking an alcoholic beverage, some alcohol (liquid or vapor) is temporarily retained in the mucous lining (the moist secreting tissues) of the mouth and the nasal passages. This is known as residual mouth alcohol. When deep lung air is exhaled, the vapor from any residual alcohol could be picked up by the deep lung air as it passes out of the mouth. Under these circumstances, mouth alcohol can cause a potentially greater concentration of alcohol in the breath sample, which in turn can cause a falsely higher BAC reading.

The effect of residual mouth alcohol is dependent upon: (1) the concentration of alcohol originally in the mouth, (2) the time the alcohol stayed in the mouth, and (3) the time elapsed since the alcohol was in the mouth. Experiments have shown that residual mouth alcohol will be eliminated by normal body processes well within 20 minutes. For this reason, the subject must be observed for 20 minutes prior to providing a breath sample.

Residual mouth alcohol contamination of a breath sample could occur in several ways other than from drinking an alcoholic beverage. First, the subject, who has alcohol in his/her stomach, could vomit and thus bring alcohol-bearing solids and liquid into the mouth cavity, producing residual alcohol. Second, a subject, who has alcohol in his/her stomach, could belch, bringing alcoholic vapor into the mouth.

Rinsing the mouth with water is not effective in eliminating mouth alcohol. Thus, when a drinking-driving subject has recently taken a drink, vomited, belched, or otherwise come in contact with alcohol, another 20-minute observation must be performed for the effects of any residual mouth alcohol to dissipate before a valid breath sample can be taken.

On occasion, a subject may have used a mouthwash in an attempt to mask the odor of an alcoholic beverage. Many mouthwashes have a significant alcohol concentration (up to 20% by volume) and should be regarded in the same manner as an alcoholic beverage. Thus, the breath test operator should be alert to the possibility of residual mouth alcohol contamination when he/she detects the characteristic odor of a mouthwash or sees the subject attempting to use a mouthwash. The foregoing also applies to cough medicines that contain alcohol. Another source of residual mouth alcohol could be an alcohol-saturated cotton wad used to relieve dental pain. The operator should always inspect the subject's mouth for any foreign objects. If found, they should be removed, and the subject must be observed for 20 minutes prior to providing a breath sample.

The Intoxilyzer Model 5000 assists the operator in assuring that there is no residual mouth alcohol in the breath sample. This is accomplished by the instrument continuously monitoring the alcohol content of the breath sample from the moment that the subject begins to blow into the instrument until he/she stops blowing. A breath sample curve from a subject without any mouth alcohol will rise evenly until it reaches a plateau, and then it will remain relatively constant as the subject submits a deep lung breath sample (Figure 8). If the subject being tested has mouth alcohol, then the alcohol curve will rise or "spike" sharply and will drop to a plateau as the mouth alcohol is dissipated and the deep lung air sample is analyzed (Figure 9). If the instrument detects a drop in BAC because of mouth alcohol, the display of the Intoxilyzer will read "INVALID SAMPLE", and a Certificate reporting this test result will be printed. **An additional 20-minute observation period must be conducted before another breath test on the same subject can be performed.**

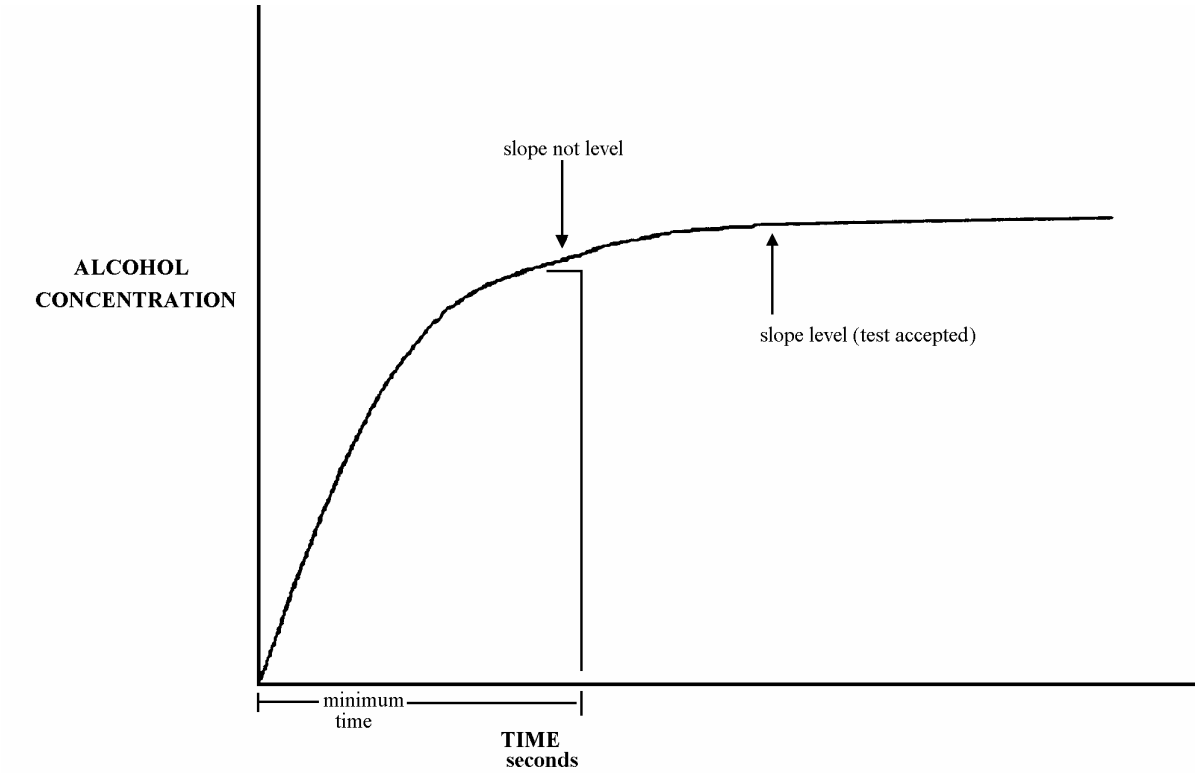

Figure 8

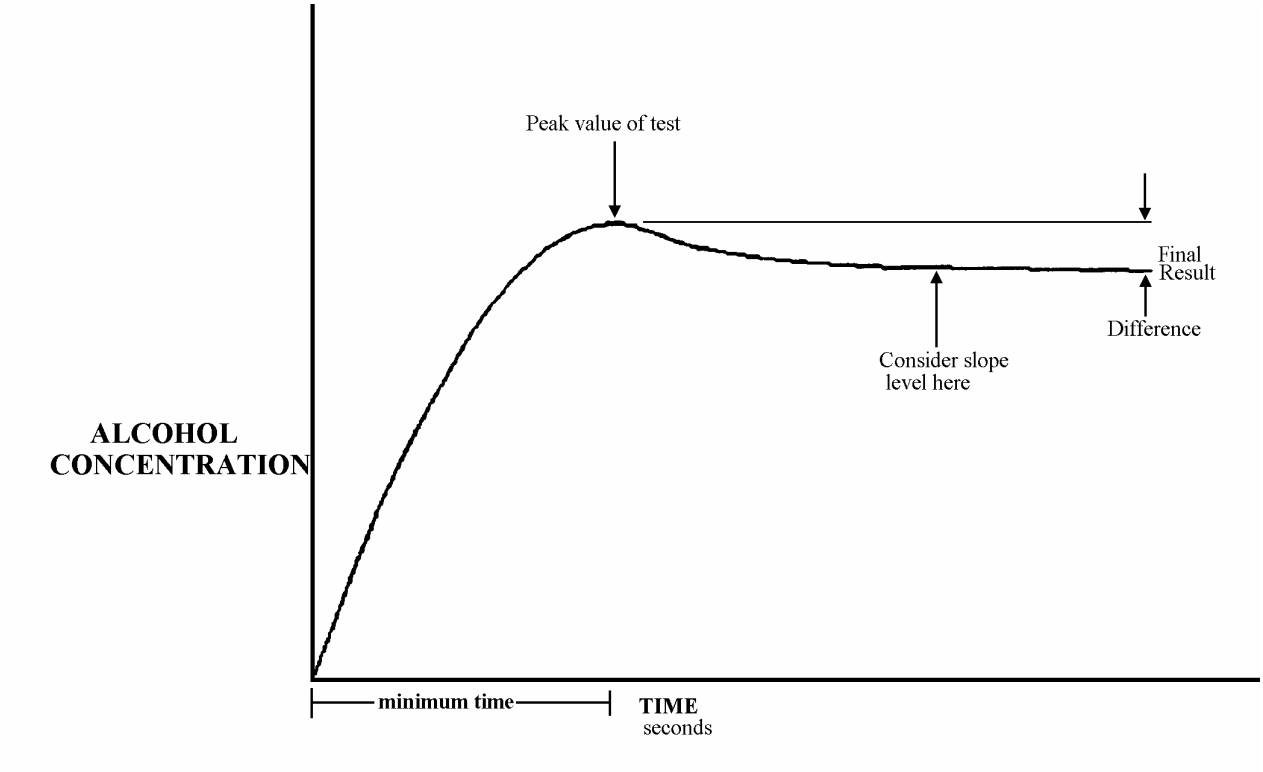

Figure 9

Figure 8 illustrates a curve of a series of alcohol readings that the Intoxilyzer Model 5000 would interpret as a normal curve that has reached level slope and would be accepted as a valid breath test. The curve in Figure 9 would be interpreted as having mouth alcohol present and would report Invalid Sample.

As a reminder: The operator should also remember to ask the subject, just prior to his giving a sample, if he/she has belched, burped or regurgitated during the observation time.

It should be noted that mouth alcohol is not the only cause for an Invalid Sample. However, if the subject is going to be retested after an Invalid Sample message, an additional 20 minute observation period must be conducted.

NOTES

NOTES

Operation

Operational Procedure

While in the scrolling mode, the Intoxilyzer 5000 will display the following in a continuous cycle: "DEPARTMENT OF FORENSIC SCIENCE", "TIME XX:XX EDT/EST", "DATE", and "PUSH BUTTON".

To start the test sequence, depress the "START TEST" button. The panel display will prompt "OPER NAME=".

At the "OPER NAME=" prompt, place the license in the card reader with the magnetic strip facing down and to the left. Guide the license up and away from the operator. The indicator light on the card reader will flash green if the proper "swiping" method has been used, which should elicit the instrument prompt "ENTER PIN NO.=". If the indicator light flashes red, an incorrect read has occurred. If the "ENTER PIN NO.=" does not appear, then position the license in the card reader and try again.

When the license has been read, the display will prompt "ENTER PIN NO.=". The operator then enters his/her five digit PIN (Personal Identification Number) followed by pressing the "ENTER" key. If the PIN entered does not match the PIN encoded on the license, the instrument will go back to scrolling Department of Forensic Science.

The instrument will check for a valid license expiration date. If the license is expired, then the instrument will indicate "EXPIRED BADGE" and reprompt "OPER NAME=".

Once the correct PIN has been entered, "OPER REVIEW Y/N" will be prompted. After the data has been reviewed, an "OPER REVIEW Y/N" prompt appears again. After "N" is entered, "SUB LAST NAME" will be prompted.

Display Reads	**Remarks**
OPER NAME=	Information is entered only by reading the magnetic strip on the Breath Alcohol Operator's License.
ENTER PIN NO.=	A PIN is read from the magnetic strip on the license. The operator enters his/her five digit PIN; the Intoxilyzer 5000 will compare the two numbers, and they must match. Invalid PIN → "INVALID BADGE" (Reswipe license) Expired license → "EXPIRED BADGE" Check license expiration date and call DFS if expired. If license has not expired, reswipe license.

(↵) means depress the ENTER key

OPER REVIEW Y/N — Type "Y" and (↵) to review the information for correctness. This information cannot be changed. If any information is incorrect, depress **F5** to return to scroll, then depress the "START TEST" button to begin at "OPER NAME" again. Careful proofreading is important to ensure that all information appearing on the Certificate of Analysis is correct.

When the data is reviewed, the display will first show the instrument prompt followed by the information swiped from the license. To move to the next prompt depress the ENTER key (↵).

OPER NAME=
↵
NAME, YOUR
↵
DFS LICENSE NO=
↵
12345
↵
DFS= (MMDDYYYY)
↵
AUG 1, 2007↵
AGENCY=
↵
ANYWHERE P.D. OR S.O.
↵
AGENCY CODE=
↵
99901
↵

OPER REVIEW Y/N — Type "N" and (↵) once all the data is correct. The Breath Alcohol Operator's License must be reswiped if any data is not correct (after depressing F5 and "START TEST").

SUB LAST NAME= — Type the last name of the subject (up to 18 characters including hyphens and spaces). Do not type the suffix with the last name.

Example = SMITH-JONES ↵

SUB FIRST NAME= Type the first name of the subject (up to 12 characters).

Example = LYLE ↵

MIDDLE INITIAL= Type the middle initial and suffix, such as Jr, Sr, III, etc., if appropriate (up to 5 characters including commas, periods and spaces).

Example = E JR ↵

DOB = (MMDDYYYY) Type the date: first by two digit month, then by two digit day, then by four digit year (MMDDYYYY). Entering an incorrect date format will return to the DOB=(MMDDYYYY) prompt. If the subject's DOB is unknown type in the current date.

Example = 01011967 ↵
January 1, 1967 (automatic advance to next screen)

SUB SEX = M/F Type the sex of the subject: M for male and F for female.

Example = M ↵

SUB DRIV LIC= Type the subject's driver's license number (up to 19 characters including spaces, hyphens or other punctuation). If the subject does not have a U.S. driver's license, press "Enter" to by-pass.

Example = T12-34-5678 ↵

STATE OF ISSUE= Type a two character state abbreviation code. (Prompt is received only when subject's driver's license number has been entered.)

Example = VA ↵

EXPIRES= (MMYY) Type the expiration date of the subject's driver's license by month and year by 2 digit month and 2 digit year (MMYY). (Prompt is received only when subject's driver's license has been entered.)

Example = 0108 (January 2008) ↵

COURT= Type the name of the court where the case will be tried (up to 30 characters including spaces and periods).

Example = ANYWHERE GENERAL DISTRICT CT ↵

SUBJ REVIEW Y/N — If entering data for the first time, press "Y" then ENTER to review the information for correctness. Once the test is started, the information cannot be changed and will be printed on the Certificate of Analysis. Continue to press "Y" and review each time the information has been changed. Do not press "N" until all information has been determined to be correct.

When the data is reviewed, the display will first show the instrument prompt followed by the typed response. To move to the next prompt, depress the ENTER key (↵). To change any subject information, use the backspace key to delete the data, and then reenter the correct data. If any entries are changed, then another SUBJ REVIEW should be performed.

SUB LAST NAME=
↵
SMITH-JONES
↵
SUB FIRST NAME=
↵
LYLE
↵
MIDDLE INITIAL=
↵
E JR
↵
DOB= (MMDDYYYY)
↵
01011967
↵
JAN 01, 1967 (Automatic advance to next screen)
SUB SEX= M/F
↵
M
↵
SUB DRIV LIC=
↵
T12-34-5678
↵
STATE OF ISSUE=
↵
VA
↵
EXPIRES=
↵
0108
↵

JAN 2008 (Automatic advance to next screen)
COURT=
↵
ANYWHERE GENERAL DISTRICT CT
↵
SUBJ REVIEW Y/N
↵
N
↵

After the operator and subject information has been entered and verified, the instrument will begin diagnostic testing:

PROM CHECK	The PROM CHECK tests to be sure that the program in the instrument is valid.
RAM CHECK	The instrument checks each byte in RAM (Random Access Memory) for possible failures. This RAM is volatile and will lose the current operator and subject data if the instrument power is removed.
TEMP CHECK	The instrument is checking the temperature of the sample chamber. The sample chamber, as well as the rest of the breath path, is heated to prevent condensation.
PROCESSOR	The Intoxilyzer 5000 display will show "PROCESSOR" until there is a response from the processor. This response is fast, and the text "PROCESSOR" may not be displayed long enough to read.
VER 75_2240 XXXX	The instrument displays the software version installed and the last four digits of the instrument serial number.
PRINTER CHECK	Communication with the external printer is tested. Information such as "PRINTER OFF LINE" or "OUT OF PAPER" is also collected and displayed at this time if necessary.
RTC CHECK	This RTC (Real Time Clock) circuit maintains the correct time and date in the instrument.
INTERNAL STD	The internal standards of the instrument are being tested.
CIRCUITRY OK	The internal diagnostic testing of the instrument is complete. All functions have passed the diagnostic tests.

This completes the diagnostic testing performed by the instrument.

MONITORING SIMULATOR TEMPERATURE	The instrument will monitor the simulator temperature for 3 minutes after it has reached operating temperature (33.8 to 34.2° C) to ensure that equilibrium has been obtained. "TIME" & "DATE" will also scroll at this point.
AIR BLANK	The instrument runs a test on the room air to ensure that no airborne contaminants are present.
SIMULATOR	The instrument runs a verification simulator test. The results of this simulator test must be within DFS allowed parameters. If the simulator test does not meet these parameters, then the instrument will prompt an "OUT OF TOLERANCE" message, print out a report reflecting this and return to scroll. Restart the test, and **if a second consecutive "OUT OF TOLERANCE" message is received, then change the simulator solution**. The results of the verification test will be shown on the instrument display for approximately 30 seconds. The operator should note this result on the appropriate place on the Operational Checklist. Once the result has been noted, "ENTER" can be pressed to clear the display allowing the instrument to continue. If "ENTER" is not pressed, then the instrument will continue with the test at the end of the 30 seconds.
AIR BLANK	The instrument runs a test on the room air to ensure that no airborne contaminants are present.
PLEASE BLOW	The Intoxilyzer 5000 is now ready for the subject to blow into the mouthpiece. A scrolling message appears: "PLEASE BLOW INTO MOUTHPIECE UNTIL TONE STOPS". A flashing: "PLEASE BLOW" appears next. The instrument allows 3 minutes from this point for a proper sample to be collected. The operator asks the subject if he/she has burped, belched, etc. during the 20 minute observation period. The operator does not proceed with the test unless satisfied that the subject has not done so. Place a mouthpiece on the breath tube and have the subject blow a long steady breath. Once the subject begins blowing into the instrument, the prompt changes to a steady "PLEASE BLOW". Immediately remove the mouthpiece from the breath tube once the instrument accepts the sample. Save the mouthpiece and use it for the next sample. If the subject refuses to blow into the mouthpiece, allow the time limit to expire and a Certificate of Blood Alcohol Analysis will be printed reading "NO SAMPLE GIVEN".
SUBJECT TEST	The instrument is analyzing the data.
AIR BLANK	The instrument runs a test on the room air to ensure that no airborne contaminants are present.

PLEASE WAIT — The instrument will not allow the next sample to be given for 2 minutes.

PLEASE BLOW — The Intoxilyzer 5000 is now ready for the subject to submit a second breath sample. A scrolling message appears: "PLEASE BLOW INTO MOUTHPIECE UNTIL TONE STOPS". A flashing: "PLEASE BLOW" appears next. The instrument allows 3 minutes from this point for a proper sample to be collected. The operator asks the subject if he/she has burped, belched, etc., since the first sample was obtained. The operator does not proceed with the test unless satisfied that the subject has not done so. Place the mouthpiece back on the breath tube and have the subject blow a long steady breath. Once the subject begins blowing into the instrument, the prompt changes to a steady "PLEASE BLOW". Immediately remove the mouthpiece from the breath tube once the instrument accepts the sample. If the subject refuses to blow into the mouthpiece, then allow the time limit to expire and a Certificate of Blood Alcohol Analysis will be printed reading "NO SAMPLE GIVEN".

SUBJECT TEST — The instrument is analyzing the data and comparing the samples.

AIR BLANK — The instrument runs a test on the room air to ensure that no airborne contaminants are present.

FINAL RESULT .XX — The instrument will display the test result. This result will be the lower of the two samples, truncated to 2 digits. If those samples differed by more than 0.02, then a third sample would have been requested, with the lowest of the three samples becoming the final result. The final result is held on the display for a period of 5 minutes and should be recorded in the appropriate space on the Operational Checklist.

Tear off, proofread, and sign the Certificate of Analysis. Record the test in the Logbook.

NOTE: The Logbook entry should not be started until the test is complete and a valid evidential test has been performed. <u>Do not log any entries other than valid evidential tests or new simulator solutions.</u>

Instrument Test

There are a few instances when an operator may want to conduct an Instrument (Practice) Test, including:

A. To check information on a new license

B. Practice Intoxilyzer 5000 operator skills.

The procedure to run an instrument test is similar to a standard breath test. When prompted for subject's last name, enter "Instrument". When prompted for subject's first name enter "Test". Supply both breath samples but **do not** record the results in the logbook. Discard the Operational Checklist and all copies of the Certificate of Analysis.

Instrument Messages and Troubleshooting

AMBIENT DETECTED	Check ambient environmental conditions to locate source.
DEFICIENT SAMPLE	Subject started blowing but did not meet required parameters for a valid test within 3 minutes of the displayed instruction to "PLEASE BLOW". A Certificate of Blood Alcohol Analysis is printed reading "DEFICIENT SAMPLE", then a "RETEST (Y/N)" prompt is displayed by the instrument.
DIAGNOSTIC OK	The instrument components and operational standards were within the allowable limits.
DISABLED	Indicates that the instrument has been disabled and will not accept the start test command. Press “H”, if SIM TEMP is displayed, press “R”. If corrective measures are not successful, then notify DFS. If you receive a message other that SIM TEMP, notify DFS.
EXPIRED BADGE	Expiration date encoded on strip shows license is expired. Verify that the license has not expired and call DFS for assistance.
INHIBITED - RFI RFI DETECTED	Radio Frequency Interference was detected.
INTERF DETECTED	A substance other than ethyl alcohol has been detected on the subject's breath. A Certificate of Blood Alcohol Analysis is printed reading "INTERFERENT DETECTED", then a "RETEST (Y/N)" prompt is displayed by the instrument. Do not retest, seek medical attention.
INVALID BADGE	Reswipe license and reenter PIN. If this corrective measure is not successful notify DFS.
INVALID SAMPLE	Primary cause is mouth alcohol. A Certificate of Blood Alcohol Analysis is printed reading “INVALID SAMPLE”, then a “RETEST (Y/N)” prompt is displayed by the instrument. If retesting the subject, begin a new 20-minute observation period.
INSTR CERT FAIL	Indicates that the instrument has exceeded the six month certification period and has disabled itself. Notify DFS.

INSTR CERT WARN	A message warning the operator that the certification of the instrument is close to expiring. Continue with test. Notify DFS.
MEMORY NEAR FULL	The instrument memory is almost full and has only enough room for approximately 10 more tests. Notify DFS.
NO SAMPLE GIVEN	No sample was received by the instrument during the 3 minute "PLEASE BLOW" prompt. A Certificate of Blood Alcohol Analysis is printed reading "NO SAMPLE GIVEN", then a "RETEST (Y/N)" prompt is displayed.
NOT READY	The instrument is warming up and initializing the computer, processor, and printer.
OUT OF PAPER	Printer is out of paper or paper is not "parked" in the correct position. Check and correct situation.
OUT OF TOLERANCE	Simulator results are higher or lower than the allowable limits of 0.090 - 0.105 grams per 210 liter of breath. Restart the test. **If a second consecutive "OUT OF TOLERANCE" message is received, change the simulator solution**.
PRINTER ERROR	Printer may be out of paper, off line and/or the power is turned off. Correct the situation until the instrument continues with the diagnostics. If corrective measures are not successful notify DFS.
PRINTER OFF LINE	Check to be sure that the printer "ON LINE" indictor is lit. Correct situation with the "ON LINE" button. If this corrective measure is not successful notify DFS.
PROCESSOR ERROR	Notify DFS.
PROM ERROR	Notify DFS.
RANGE EXCEEDED	Sample given was in excess of 0.60 grams per 210 liters of breath. Seek medical attention.
RAM ERROR	Notify DFS.

RETEST (Y/N) This message is displayed by the instrument after "DEFICIENT SAMPLE", "NO SAMPLE GIVEN", "INTERF DETECTED" and "INVALID SAMPLE". A Certificate of Blood Alcohol Analysis is printed, and the instrument displays "RETEST (Y/N)". If "Y" is pressed, then all of the entered information is retained and the instrument will run the diagnostic checks and simulator verification test until prompting "PLEASE BLOW INTO MOUTHPIECE UNTIL TONE STOPS" then a flashing "PLEASE BLOW". If "N" is pressed the instrument returns to the scrolling mode.

SEQUENCE Incorrect sequence during testing. Restart the test.

SIM TEMP The simulator solution is outside of the operating temperature range (33.8-34.2° C). Press “R”, and the instrument will monitor the temperature and return to scrolling when operational. If this corrective measure is not successful notify DFS.

SOL CHANGE FAIL The instrument has reached either the maximum number of tests or the maximum number of days since the last simulator solution change. Upon exceeding either limit, the instrument will disable itself. Notify DFS.

SOL CHANGE WARN The number of simulator solution tests is approaching the maximum number, which begins within ten tests or five days of expiring. Change simulator solution.

TEMP ERROR Notify DFS.

UNSTABLE REFERENCE Instrument electronics are not stable. Notify DFS.

Aligning Forms

1. Press the LOAD PARK Button (1st - Forms will retract, 2nd - ON LINE Indicator will go out, and 3rd - POWER/PAPER OUT Indicator will flash).

2. Press LOAD PARK again (1st - Forms will advance, 2nd - POWER/PAPER OUT Indicator will light).

3. Press the ON LINE Button (The ON LINE Indicator will light.)

Forms will now be properly aligned for printing. Press F1 to reprint a Certificate of Analysis if the START TEST Button has not been pressed.

Loading Forms

1. Remove printer Top Cover.

2. Open Tractor Covers
(Refer to Figure 10.)

3. Align 3 - 4 holes of form on one of the tractors and close the tractor cover.

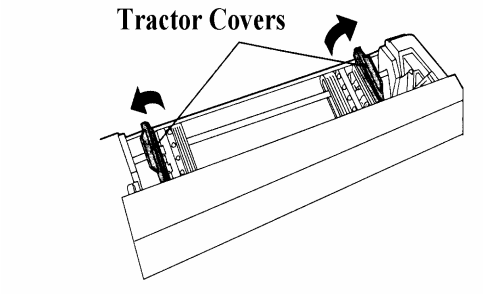

Figure 10

4. Align other side of form on the opposite tractor (same number of holes for each tractor) and close the tractor cover.

5. Press LOAD PARK Button (1st - Forms will advance, 2nd - POWER/PAPER OUT Indicator will light).

6. Press the ON LINE Button. (The ON LINE Indicator will light.)

7. Replace Top Cover.

Forms will now be properly aligned for printing. Press F1 to get a properly printed Certificate if the START TEST Button has not been pressed.

NOTES

NOTES

SCIENTIFIC CONCEPTS AND SAMPLE ANALYSIS

Systems of Measurement

Measurement systems have been used by man since before the written word developed. Man used units of length corresponding to the human hand or foot. Units of weight included a stone, and units of volume included a cupped hand. The U.S. system of measurement is based on standards such as those above that have been standardized over the years. Some of the units of measure in the U.S. System of measurement are:

Length	-	inches, feet
Weight (Mass)	-	ounces, pounds
Volume	-	ounces, pints, quarts, gallons

The Metric System

The metric system is used exclusively by every industrialized nation in the world except the United States. This system is utilized in the United States for scientific measurements. The three basic units of measure in the metric system are:

Length	-	Meter (m)
Mass (Weight)	-	Gram (g)
Volume	-	Liter (L)

Division of Metric Units

The metric system is a base 10 system. Each base unit -- meter, liter, or gram (m, L, g) -- becomes a larger or smaller quantity by adding a prefix to the unit. Some prefixes are listed below:

deka = 10 units	deci = 1/10th unit
hecto = 100 units	centi = 1/100th unit
kilo = 1000 units	milli = 1/1000th unit
mega = 1 million units	micro = 1/1 millionth unit

For example, 1 dekagram is 10 grams, 1 centiliter is 1/100th of a liter, 1 kilometer is 1000 meters and 1 milliliter is 1/1000th of a liter, etc.

Another way of comparing these units is shown below:

Length		Weight		Volume
1 millimeter (mm)		1 milligram (mg)		1 milliliter (ml)
10 mm = 1 centimeter (cm)		10 mg = 1 centigram (cg)		10 ml = 1 centiliter (cl)
10 cm = 1 decimeter(dm)		10 cg = 1 decigram (dg)		10 cl = 1 deciliter (dl)
10 dm = 1 meter (m)		10 dg = 1 gram (g)		10 dl = 1 liter (l)
10 m = 1 dekameter (dkm)		10 g = 1 dekagram (dkg)		10 l = 1 dekaliter (dkl)
10 dkm = 1 hectometer (hm)		10 dkg = 1 hectogram (hg)		10 dkl = 1 hectoliter (hl)
10 hm = 1 kilometer (km)		10 hg = 1 kilogram (kg)		10 hl = 1 kiloliter (kl)

The metric system is easy to work with because it is a base ten system. Suppose you were asked: "How many centimeters (cm) are there in 6.8 kilometers (6.8 km = ? cm)?"

The following will be useful in understanding the base ten system:

Kilo	Hecto	Deka	Unit	Deci	Centi	Milli			Micro
|	|	|	|	|	|	|	|	|	|
1000	100	10	1	.1	.01	.001			.000001

Example

6.8 km = ? cm (from above)

Now convert kilometers (kilo) to centimeters (centi) on the above scale. From kilo to centi is 5 spaces to the right. Take the 6.8 and move the decimal point 5 places to the right (the same direction that you moved on the scale). Thus:

6.80000 Insert 0s and move the decimal point: 680,000

Therefore: 6.8 km = 680,000 cm

The same scale can be used in going from smaller to larger units by moving the decimal point to the left instead of to the right.

Conversion from One System to the other

The U.S. system can be converted to the metric system using the following:

Length:	1 meter	=	39.37 inches
Weight:	1 gram	=	0.035 weight ounces
Volume:	1 liter	=	1.06 quarts

Temperature Systems

Temperature is defined as the difference of heat as measured on a definite scale. There are several different temperature scales. When operating the Intoxilyzer, both the Fahrenheit and Celsius temperature scales and their relationships to each other are important.

Fahrenheit

This scale is based upon a difference of 180 units (degrees) between the temperature of melting ice (32° F) and the boiling point of water (212° F). Fahrenheit is commonly used in the U. S. for non-scientific temperature measurement.

Celsius (centigrade)

This scale is based upon a difference of 100 units (degrees) between the temperature of melting ice (0° C) and the boiling point of water (100° C). Also referred to as the centigrade scale, this system is used throughout the world in both the scientific and non-scientific communities.

Celsius and Fahrenheit Scale Relationships

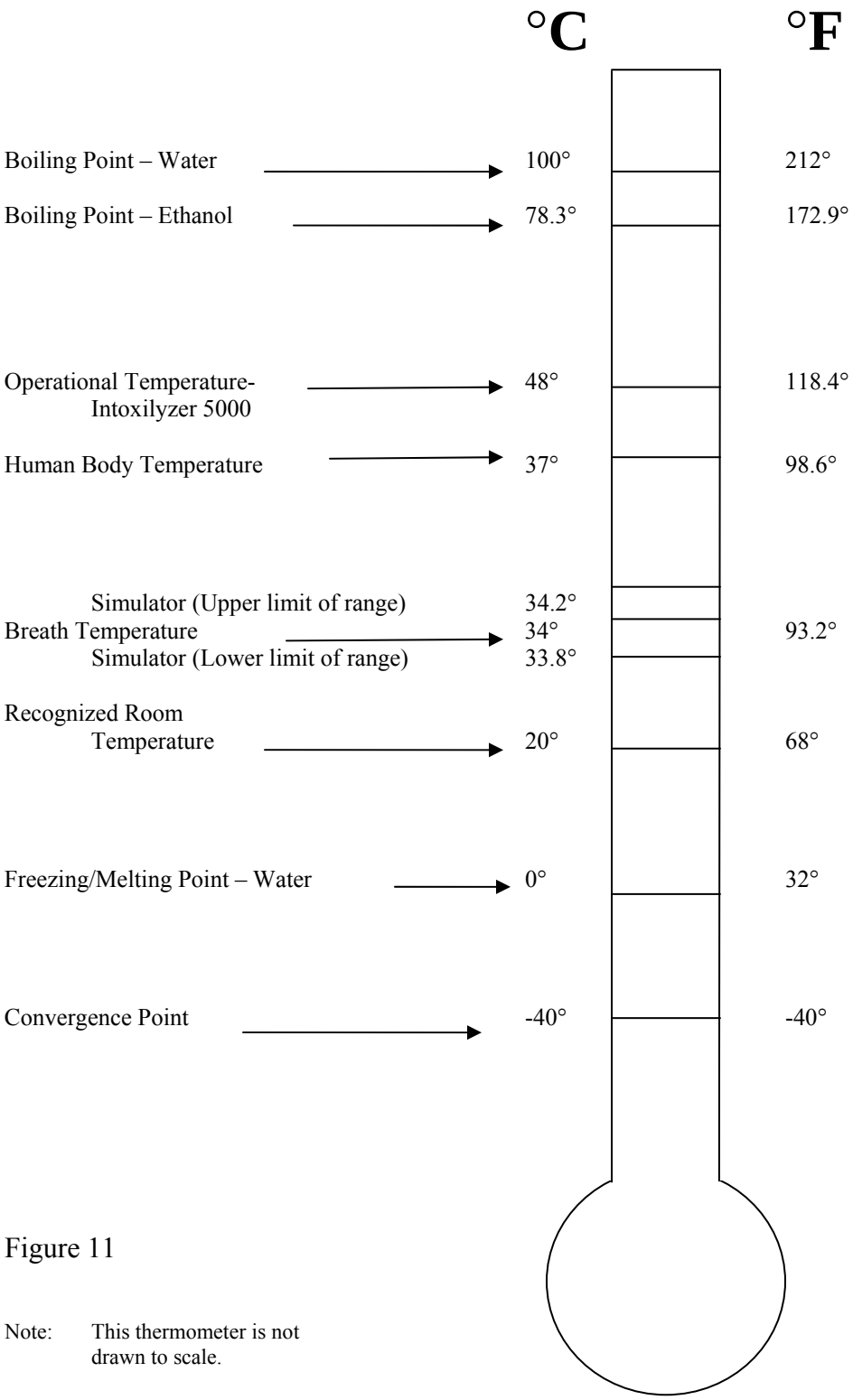

Figure 11

Note: This thermometer is not drawn to scale.

The Simulator Thermometer

The approximate temperature of human breath as it leaves the mouth is 34° C. Since the simulator is designed to "simulate" a drinker, it operates at approximately 34° C. The actual operational temperature range is 33.8 to 34.2° C.

Note that the simulator thermometer range is 33.5 to 34.5° C. The mercury in the thermometer of a properly operating simulator will be within 33.8 to 34.2° C as shown by the lightly shaded area of Figure 12.

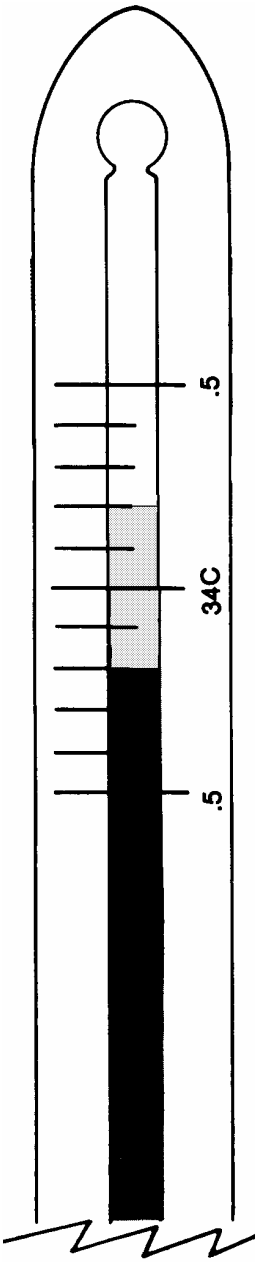

Figure 12

BREATH TESTING

A small yet measurable portion of alcohol is eliminated through the breath. This makes breath alcohol testing possible, and as such, it provides the reliable basis by which the amount (concentration) of alcohol in the blood can be determined.

Breath alcohol analysis is based on the fact that the distribution of alcohol between circulating blood and deep lung air occurs by diffusion and obeys Henry's Law.

Henry's Law:

The weight of any gas that dissolves in a definite volume of liquid is directly proportional to the vapor pressure that the gas exerts above the liquid. This proportion differs at varying temperatures, pressures, and volumes.

Discussion:

If a closed bottle partially filled with a solution of alcohol and water is shaken, some of the alcohol will transfer from the solution and mix with the air in the bottle. This air/alcohol mixture will reach a certain concentration and will stop. This point is known as **equilibrium.** At equilibrium, for any given temperature and pressure, there will be a definite ratio between the amount of alcohol in the air and in the water. The higher the temperature, the more alcohol will be in the air. Conversely, the lower the temperature, the less alcohol will be in the air. This ratio can be expressed as follows:

$$\frac{\text{Wt. of Alcohol per vol of air}}{\text{Wt. of Alcohol per vol of water}} = k \text{ (a constant)}$$

Thus, if the value of the constant (k) and one of the other values is known, then the third value can be calculated.

Application to Breath Testing

Alcohol obeys Henry's Law because there is a distribution equilibrium. Therefore at a given temperature, a constant ratio exists between the concentration of alcohol in the blood and in deep lung air. The average temperature at which the breath leaves the mouth is 34° C. Therefore, the ratio between the concentration of alcohol in blood and deep lung air with which it is in equilibrium must be determined at 34° C. This ratio is 2100:1, which means that 2100 ml of deep lung air contains the same quantity of alcohol as 1 ml of arterial blood.

The Respiratory System

The respiratory system appears as an inverted tree (Fig.13). The trunk is the windpipe (trachea) which then separates into 2 branches (bronchus). The branches are inside the lungs and continue to branch out until they end in microscopic sacs (alveolus). This alveolar region is where gas exchange takes place. Where blood vessels come in contact with the alveolar sacs there is an exchange of oxygen from the deep lung air into the blood and an exchange of carbon dioxide from the blood into deep lung air. Likewise, any alcohol present in the blood will also transfer into deep lung air. When this occurs, the deep lung air will contain approximately 1/2100th as much alcohol as the blood.

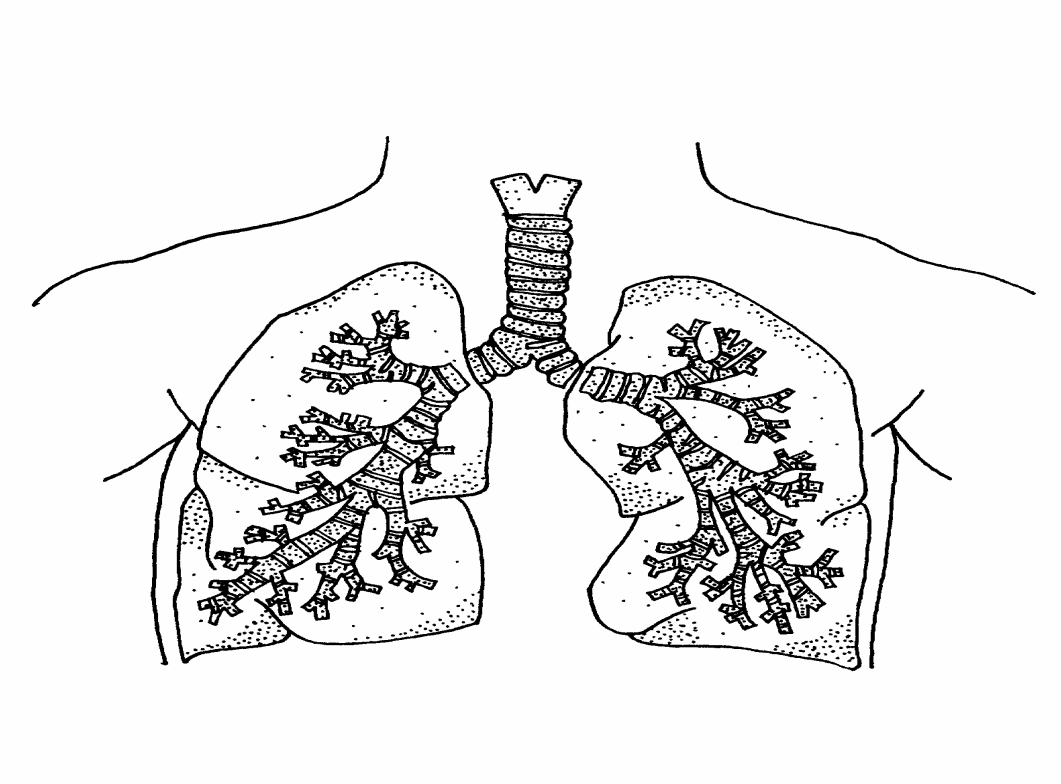

Figure 13

In addition, Henry's law also pertains to the simulator used in the verification test. The simulator operates within a temperature range of 33.8 to 34.2°C, which will maintain a constant alcohol/water ratio which will produce a constant alcohol/air ratio.

Infrared Theory

The Intoxilyzer Model 5000 uses infrared (IR) light and five ethanol-specific IR filters to identify the ethyl alcohol molecule and to determine the percent of alcohol in a breath sample. To better understand infrared theory with respect to evidential breath testing, a basic knowledge of the electromagnetic spectrum is helpful.

The electromagnetic spectrum is a series of wave energies that begin far below radio waves and extends to cosmic waves. The visible light spectrum is a narrow band within the electromagnetic spectrum. Visible light, those frequencies detected by the human eye, contain all colors of the rainbow or those colors seen when passing white light through a prism. Not all light is visible to the human eye, particularly ultraviolet (UV) and infrared (IR). These wavelengths fall just outside the visible light spectrum as shown in Figure 14.

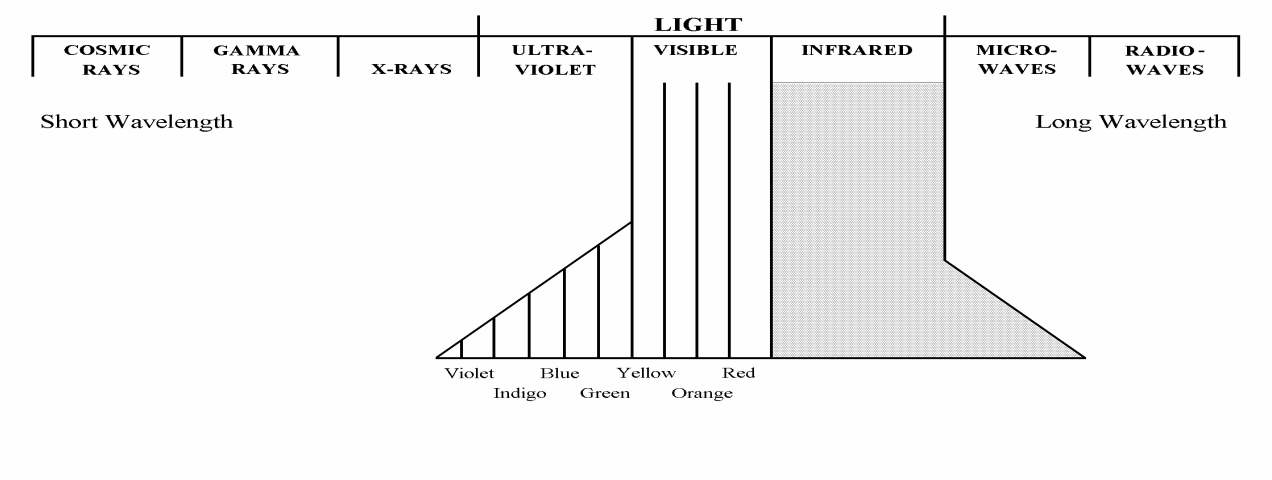

Figure 14

Historically, infrared light has been used to identify chemical compounds. When infrared light is passed through a substance, some of the infrared light (energy) will be absorbed. Absorption occurs at different wavelengths and is dependent upon the molecular structure of the compound being tested. The molecules of any compound are composed of individual and uniquely arranged atoms. Each substance, therefore, will have a unique infrared pattern or spectrogram.

This absorption of light can be explained by the Beer-Lambert Law. Which states: "If a light is directed through a container, the amount of light detected on the other side of the container is decreased by any substances in the container in proportion to their absorption coefficients and concentrations, and is also decreased in proportion to the distance across the container."

If a variable infrared light source is directed through a group of molecules, such as ethyl alcohol, then an infrared spectrogram can be produced. Each substance has its own particular spectrogram. The instrument used to produce an IR spectrogram is an infrared spectrophotometer. The instrument must have as a minimum:

(1) an infrared source,
(2) a method of breaking down the IR spectrum into its component parts,
(3) an IR detector,
(4) a sampling device or system, and
(5) a means of producing a spectrogram

Ethanol, or ethyl alcohol, is composed of carbon, hydrogen, and oxygen atoms arranged as shown in Figure 15.

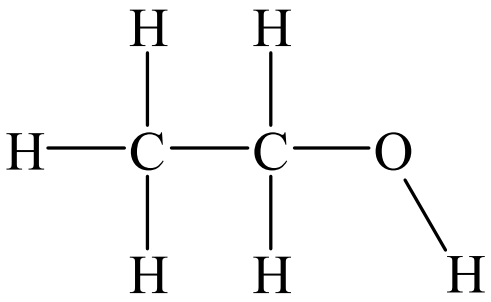

Figure 15

Operational Theory

An understanding of the operational theory of the Intoxilyzer 5000 is important since the instrument uses infrared light to conduct chemical tests for ethanol. The operator should have a basic working knowledge of key components, such as the sample chamber, infrared filters, the detector, and the processor.

The sample chamber, contained in the Intoxilyzer 5000, has a volume of 81.4 ml and is heated to a temperature of 48°C. This temperature prevents condensation from forming in the system. The system is designed to be an open system with no restrictions so that the subject can easily provide a breath sample. The breath sample moves continuously from the inlet to the outlet and does not accumulate in the chamber.

At one end of the sample chamber a quartz iodide lamp emits infrared energy which is directed through the sample chamber by a lens. At the other end of the sample chamber a second lens focuses the energy through five filters located in the rotating filter wheel to an infrared energy detector. The detector "reads" the amount of infrared energy it receives and sends this information to the processor. The processor determines the amount of infrared energy that is absorbed by the detector and, therefore, can determine the concentration of ethyl alcohol in the sample.

In the Intoxilyzer 5000, the initial energy intensity is established. The absorption coefficient for ethyl alcohol is known at each wavelength (filter value), and the length of the energy path is equal to the length of the sample chamber. Therefore, the concentration of any ethyl alcohol in a given sample can be determined based upon the final intensity as measured by the instrument detector.

Because the Beer-Lambert Law is independent of volume, the Intoxilyzer 5000 instantaneously and continuously analyzes the sample present without being dependent upon a fixed sample volume required by chemical reaction (oxidation/reduction) type instrumentation.

Thus, the greater the concentration of ethyl alcohol in the sample, the more infrared light it will absorb. This is measured by the Intoxilyzer 5000 detector and is reported in grams of alcohol per 210 liters of breath.

Sample/Analysis System

The heart of the Intoxilyzer 5000 is the sample/analysis system. This can be further broken down into the sample system and the IR detection system. As shown in Figure 16, it is composed of the following:

IR Lamp The IR lamp is the source of infrared energy used by the instrument in the analysis.

Sample Chamber The sample flows through the sample chamber as it is being analyzed.

Filter Wheel The filter wheel contains the five infrared filters.

Detector The detector measures the amount of infrared energy passing through the sample chamber.

Processor The processor evaluates the signals from the detector in order to make a final determination of the conditions of the sample.

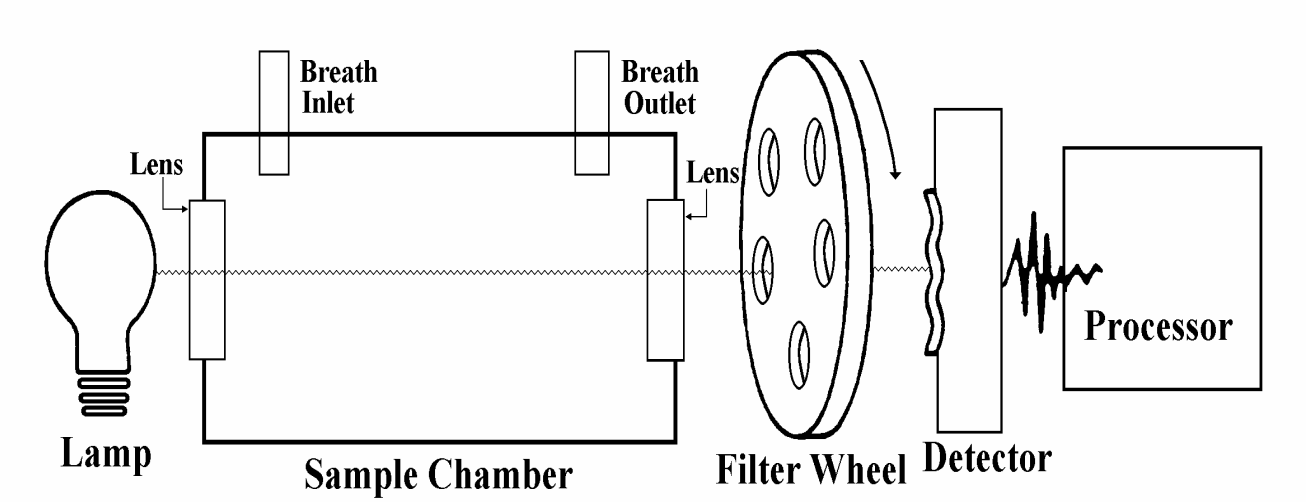

Figure 16

The Intoxilyzer Model 5000, by selectively filtering the energy from the IR light source, can identify and measure the amount of absorption in a narrow region of the infrared spectrum. This is accomplished by using five IR filters to analyze the ethyl alcohol molecule between 3 and 4 microns. (1 micron = 1 millionth of a meter.)

By using five filters, characteristic points of the ethanol IR spectra can be examined, allowing the Intoxilyzer to get a better "look" at that area of the spectra. This makes the identification of ethyl alcohol much more specific. The chances of another compound having the same IR pattern in the 3 - 4 micron area is remote. (See Interfering Substances on page 47.) A diagram of the IR absorption of ethanol between 3-4 microns is shown in Figure 17.

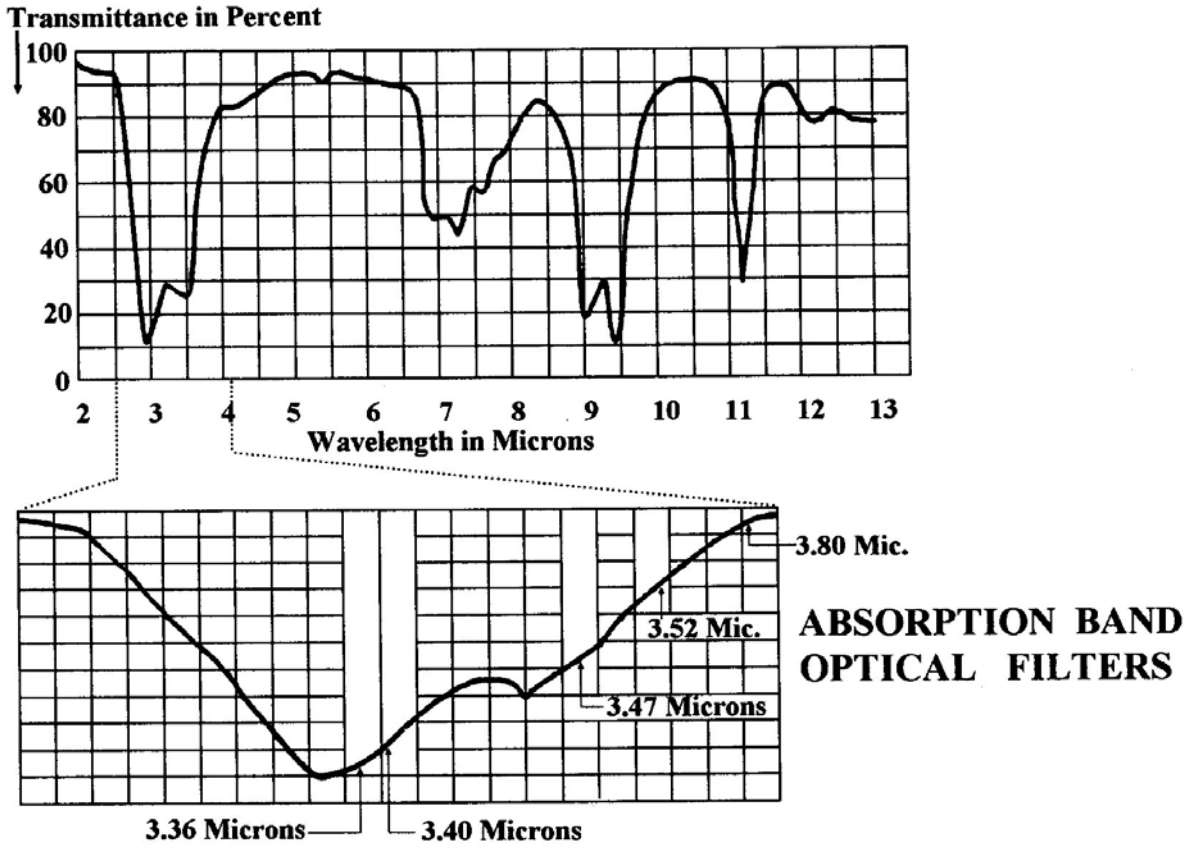

Figure 17

Interfering Substances

The detector reads the signal through five filters, and the processor analyzes these readings to ensure that they are consistent with ethyl alcohol. One of the filters is used as a reference and reads an area where no breath constituents absorb infrared light. Any readings inconsistent with ethyl alcohol are evaluated by the processor for interfering substances. If the presence of an interfering substance at a level of 0.01 grams per 210 liters of breath or greater is detected, then the Intoxilyzer 5000 will abort the test and display an "INTERF DETECTED" message and will print a Certificate of Analysis which reads "INTERFERENT DETECTED ". If the level of an interfering substance is less than 0.01 grams per 210 liters of breath, the instrument will correct the ethyl alcohol (if any is present in the sample) reading.

Persons with diabetes, as they approach diabetic coma, can exhibit many of the symptoms associated with being under the influence of alcohol. A person in this condition will produce acetone on the breath. Because the Intoxilyzer 5000 evaluates five different areas of the 3 to 4 micron IR spectrum, the presence or absence of acetone can be determined. If the presence of acetone at a level of 0.01 grams per 210 liters of breath or greater is detected, then the Intoxilyzer 5000 will abort the test and display an "INTERF DETECTED" message and will print a Certificate of Analysis which reads "INTERFERENT DETECTED ". If the level of acetone is less than 0.01 grams per 210 liters of breath, the instrument will correct the ethyl alcohol (if any is present in the sample) reading.

Toluene is a solvent used in many oil based paints, plastic modeling cements and some floor covering adhesives. This solvent can be encountered in various industrial applications and can be abused through intentional "sniffing." A person can inhale toxic levels of toluene and could exhibit some of the symptoms associated with being under the influence of alcohol. The Intoxilyzer 5000, when evaluating the breath sample, will detect toluene if it is present in the breath. If the presence of toluene at a level of 0.01 grams per 210 liters of breath or greater is detected, then the Intoxilyzer 5000 will abort the test and display an "INTERF DETECTED" message and will print a Certificate of Analysis which reads "INTERFERENT DETECTED ". If the level of toluene is less than 0.01 grams per 210 liters of breath, the instrument will correct the ethyl alcohol (if any is present in the sample) reading.

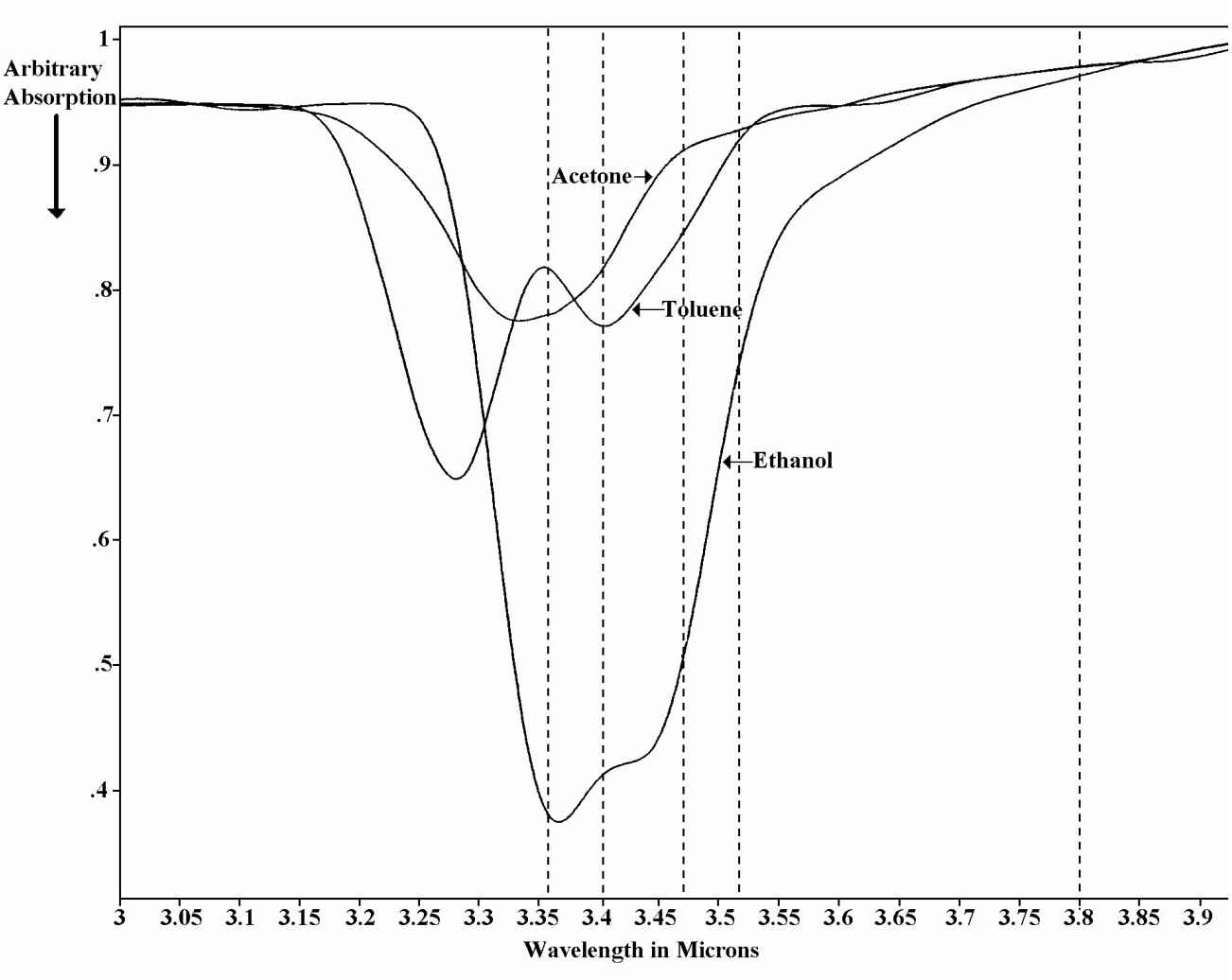

Figure 18

Figure 18 shows the differences between ethyl alcohol, acetone and toluene in the 3 - 4 micron infrared region.

ALCOHOL

Nomenclature, Types, and Production of Alcohol

Alcohol is an organic compound containing carbon and hydrogen atoms and a hydroxyl (-OH) group. The most frequently encountered alcohols are infinitely soluble in water, weak acids, and are clear and colorless. Various types of alcohols have their own respective properties and toxicities, and as such, death will result if a sufficient quantity is consumed or otherwise introduced into the body. Different alcohols have varying levels of toxicity because metabolism by the body forms different products as seen in the table below.

COMMON ALCOHOLS				
NAME	FORMULA	BOILING POINT	USES	TOXICITY & METABOLITES
Methanol methyl alcohol wood alcohol	CH_3OH	64.5° C	Denaturant Solvent Paint Remover Fuel	~ 75 ml Formaldehyde
Ethanol ethyl alcohol grain alcohol	C_2H_5OH	78.3° C	Beverage Solvent Medicinal Veh. Fuel	~ 400 - 500 ml Acetaldehyde
Isopropanol isopropyl alcohol rubbing alcohol	C_3H_7OH	82.3° C	Denaturant Antiseptic	~ 250 ml Acetone
Butanol butyl alcohol	C_4H_9OH	117° C	Perfume and Aftershave Base	~ 100 ml

Table 1

Properties of Alcohols

Alcohols are clear, colorless liquids with odors which tend to increase in complexity and intensity proportionally with their formula. Other properties of alcohols are:

Antiseptic. Alcohols can be used as antiseptics. Since they are freely miscible with water, they tend to "dry out" the "germs" in the areas treated with the alcohol.

Diuretic. Alcohol increases urine production.

Drug. Alcohols, especially ethyl alcohol, are classified as drugs and act as central nervous system (CNS) depressants. Therefore, they are often classified as anesthetics.

Food. Alcohol can be classified as a food since it produces heat (calories) during metabolism; however, alcohol and its metabolites have no nutritional value.

Miscible. Alcohols are infinitely soluble in water. Alcohols will not settle out of solution, even upon sitting because of this affinity for water.

Poison. Alcohols are poisons, whether by acting on the CNS or by producing toxic metabolites as the body oxidizes them.

Vasodilator. Alcohol tends to dilate (make larger) the blood vessels in the body. This dilation can be especially noticeable in the surface blood vessels in the nose and face.

Ethyl Alcohol

Ethyl alcohol (ethanol) is the specific alcohol present in alcoholic beverages. In its pure state, ethyl alcohol is a colorless liquid with a slight odor. Because the odor is delicate, it will often go unnoticed. Ethanol also produces a burning sensation. Simply stated: Ethyl alcohol is a clear, colorless, essentially odorless liquid that has a burning taste.

Production of Ethyl Alcohol

Ethyl alcohol can be produced both naturally by fermentation and synthetically. Synthetic production is usually accomplished by breaking down petroleum products during the refining process. This alcohol is used for industrial purposes and it is not sold for human consumption. Thus, synthetically produced ethanol is denatured (poisoned) to discourage consumption. Methanol and isopropanol are frequently used to denature industrially produced ethanol. Consumption of denatured ethanol can be very unpleasant and possibly lethal.

By law, all ethanol for human consumption must be produced by fermentation. Any plant matter such as grains, fruits, or vegetables containing 12 - 15% sugar can be used as a source for ethanol production. Yeast, either naturally occurring or added as a pure culture, ferments the sugar and produces ethanol and carbon dioxide.

Three Major Types of Alcoholic Beverages

Fermented. Beer and wine are the most commonly fermented beverages. These beverages are produced by allowing the fermentation process to take place, filtering the beverage, and then packaging it for use. In the U.S., beer typically has an alcohol content of approximately 4%, whereas wine usually has an alcohol content of 10 - 12.5%. If conditions are optimal, then the maximum alcohol content attained by fermentation is approximately 15%.

Distilled. Whisky, rum, vodka, etc. are distilled beverages produced by fermenting their respective raw materials (grains, molasses, potatoes, beets, etc.). Next, the resultant mixture is distilled, a process where the mash, wine, or other alcohol-containing mixture is heated. When a solution of alcohol and water is heated, the alcohol will boil first, since it boils at 78.3° C. As the alcohol boils, the vapors are collected and condensed. This alcohol is then used to produce a distilled beverage, which contains a higher alcohol content than a fermented beverage.

Fortified. Fortified wines are the most common beverages of this type. Fortified wines typically contain 18 - 20% alcohol and can be even higher in alcohol content, which is achieved by either adding alcohol from another source or by distillation. Wine is distilled to separate the alcohol from the fruit juice. A portion of the fruit juice is removed for use in other food products, and the distilled alcohol is mixed with the remaining fruit juice to produce a fortified wine.

Congeners

In addition to alcohol and water, alcoholic beverages contain numerous compounds or impurities known as congeners. These typically impart a characteristic color, flavor, and odor to the beverage. They constitute a very small portion (1% or less) of the total volume of the beverage.

Proof System

In the United States, the proof of an alcoholic beverage is twice the percentage of alcohol by volume. Thus, an 86 proof (also written 86°) bottle of whiskey contains 43% alcohol by volume. Most alcoholic beverages have a maximum of approximately 50% alcohol by volume. The remainder consists of water and congeners.

BEVERAGE TYPE	METHODS OF PRODUCTION	APPROXIMATE % ALCOHOLIC CONTENT (W/V)
Beer	Brewing/fermentation of cereals	3.5 - 6
Brandy	Distillation of fruit juices	50
Champagne	Fermentation of grape juice	10 - 14
Cider	Fermentation of apples	8 - 10
Gin	Distillation of cereals	40 - 50
Vodka	Distillation of potatoes, sugar beets	40 - 50
Whiskey	Distillation of corn, barley, rye, wheat	40 - 50
Wine, Fortified	Fermentation of grapes with addition of brandy	14 - 30
Wine, Red & White	Fermentation of red and white grapes	10 - 14

Source: Shipley, C. V., Chemical Tests Manual, Kentucky Traffic Safety Institute, Eastern Kentucky University, 1970, pg. 2.

Table 2

PHYSIOLOGY

When consumed, alcohol follows a path through the esophagus and into the stomach. While in the stomach, some of the alcohol will be absorbed unchanged into the bloodstream before passing to the small intestine. Most of the remaining alcohol will be absorbed from the small intestine into the blood and carried to all parts of the body.

Since alcohol has an affinity or attraction for water, alcohol will accumulate in the body tissues in proportion to their water content. Once absorbed into the bloodstream, the body immediately starts to metabolize the alcohol. This metabolism is largely accomplished in the liver where the alcohol is ultimately oxidized to carbon dioxide and water.

The following discusses the absorption, distribution, and elimination of alcohol in the body.

Routes of Absorption

Absorption from Gastrointestinal Tract. Alcohol is absorbed by various parts of the gastrointestinal tract as follows:

-- Alcohol can be absorbed through the mouth lining: however, the amount is normally insignificant since fluid leaves the mouth rapidly. A mouth rinsed with liquor will be free of residual alcohol in less than 20 minutes.

-- Approximately 25% of ingested alcohol is absorbed directly into the bloodstream through the stomach wall. The exact amount is variable and influenced by the emptying time of the stomach. The emptying of alcohol from the stomach to the small intestine is controlled by the pyloric valve which opens and closes at the base of the stomach.

-- The remaining ingested alcohol (~75%) is absorbed unchanged from the small intestine into the hepatic portal vein. Most of this absorption occurs in the duodenum (the first 8-12 inches of the small intestine).

Inhalation. Ethyl alcohol is readily absorbed by lung tissue. Animals have become severely intoxicated by breathing alcohol fumes in confined spaces; nevertheless, in humans, a concentration of alcohol high enough to produce a significant rise in blood levels would irritate the tissue lining the esophagus.

Injection. Alcohol is detectable in the blood almost immediately after injection into a muscle, or instantaneously when administered intravenously.

Insertion. When given as an enema, alcohol is readily absorbed by the large intestine (colon).

Skin Contact. Experiments have shown that no detectable blood levels have been obtained from alcohol rubs when the subject could not inhale the alcohol.

Rate of Absorption

Absorption rates vary somewhat from person to person. Individual absorption rates can also vary depending on the condition of the body. Alcohol begins to pass into the bloodstream within one to two minutes after it is consumed. Nearly all of the ingested alcohol is absorbed within 45 minutes. During normal social drinking conditions, alcohol is often absorbed in less than 30 minutes.

Factors that Affect the Rate of Absorption.

Dilution	The concentration of alcohol in the beverage can affect absorption. Strong solutions irritate the gastrointestinal walls and often inhibit absorption.
Pattern of Consumption	The period of time over which one ingests the alcohol can affect the time it takes to reach the peak (highest) alcohol concentration.

Distribution

Route. Alcohol is absorbed into the blood through the walls of the stomach and small intestine. Alcohol travels via the hepatic portal vein to the liver and then travels via the circulatory system to the heart, lungs and then back to the heart. The heart then pumps alcohol to all parts of the body.

Equilibrium. Alcohol has an affinity for water and distributes itself through the body organs and tissues in proportion to their water content. Blood circulates through the body at a rate of 3 to 4.5 liters per minute. Some organs such as the brain, liver, and kidneys have large blood supplies. Because of this large blood circulation, the alcohol content of the brain elevates quickly, resulting in rapid impairment. When absorption and distribution are complete, equilibrium occurs. Alcohol distribution is proportional to water content.

Distribution ratios. The distribution ratios given in Table 3 are for the amount of alcohol in tissues and body fluids compared to that in whole blood, which has been assigned a value of 1.00. The values given are averages.

Distribution ratios

Whole Blood	1.00
Urine	1.35
Blood Plasma	1.12 (approx.)
Saliva	1.12
Liver	0.92
Brain	0.86 (approx.)
Fat	0.019

Table 3

The Human Digestive System and the Route of Alcohol

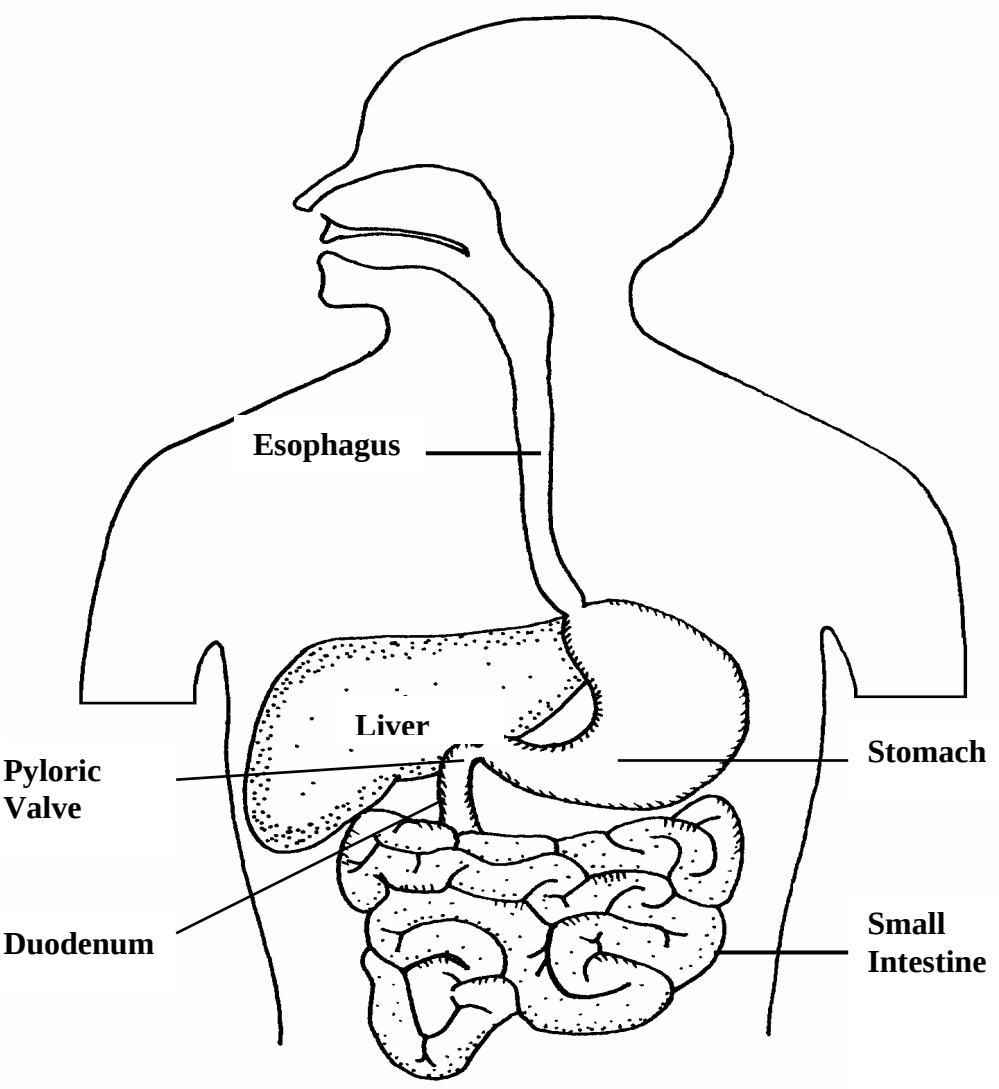

Figure 19

The Human Digestive System and the Route of Alcohol. When alcohol is taken by mouth, it passes down the esophagus to the stomach, through the pyloric valve and into the duodenum where it is absorbed by the hepatic portal vein and into the blood supply. (Fig. 19) The blood then distributes the alcohol to all parts of the body including the liver. Alcohol is oxidized in the liver to acetaldehyde, then to acetic acid, and is eventually converted to carbon dioxide and water.

Endogenous Alcohol. Endogenous alcohol refers to alcohol that exists "normally" in the body regardless of whether or not a person consumes alcoholic beverages. Experts disagree as to whether or not endogenous alcohol actually exists. Both endogenous methyl and ethyl alcohol have been reported in research literature; nevertheless, the values have not exceeded a BAC of 0.003 and generally are less than 0.001.

Widmark's Formula. E. M. P. Widmark, a Swedish scientist and pioneer in alcohol research, developed a formula for estimating the amount of alcohol needed to produce a given BAC. This formula is based on the distribution of alcohol in the body as a whole to blood. This formula, although an estimate, is the basis for many of the BAC charts.

Elimination. Ethyl alcohol is eliminated from the body both by metabolism and by direct excretion.

Metabolism. Most alcohol (between 90% and 98%) is oxidized in the liver by an enzyme, alcohol dehydrogenase. Since oxidation provides the body with calories (a form of heat), alcohol can be considered a food. In this case, however, it provides no nutritional value.

Excretion. A small amount of alcohol is excreted directly through the breath, urine, tears, saliva, perspiration, etc. The amount excreted varies between 2% and 10% of the quantity absorbed.

Rate of Elimination. As soon as alcohol is absorbed into the blood system and travels to the liver, the body immediately starts to eliminate it. The average rate of elimination ranges from 0.015 to 0.018 g/210L breath per hour. For any given person at a given time, the rate of alcohol elimination per hour will be essentially constant.

Factors Affecting Rate of Elimination. In general, the rate of elimination is not affected by stimulants, diseases and/or exercise. When rate changes have been noted, they are too small to be of any practical value. Any attempts aimed at eliminating alcohol through increased breathing rate, urination, and/or perspiration have little or no effect because the quantity excreted is so small.

PHARMACOLOGY

Pharmacologically, ethyl alcohol is the intoxicating compound in alcoholic beverages and produces those effects commonly associated with drinking. The effect of alcohol on the brain causes physical changes within the drinker. (refer to Table 4)

Effects on the Central Nervous System. Alcohol is a depressant and not a stimulant. While alcohol appears to have a stimulant effect on the central nervous system because it decreases one's inhibitions, it is actually a depressant at all doses. Alcohol influences the most recently developed portion of the brain first, the part controlling a person's judgment and inhibitions. The last area of influence is on the oldest and most developed portion of the brain, that which controls the automatic body functions. Large doses of alcohol over a short period of time may result in coma and eventually death due to respiratory failure.

Effects on Reaction Time and Coordination. Alcohol causes an impairment in muscular coordination. The threshold of impairment has been demonstrated to be as low as a BAC of 0.02 g/210 liters of breath. Reaction time is increased. Each person appears to have a threshold BAC at which impairment begins, then small additional doses of alcohol produce large losses in coordination. Motor tasks which require coordination and complex discrimination are impaired at a BAC as low as 0.05 g/210 liters of breath.

Effects on Vision. Visual acuity is generally not affected until the BAC exceeds 0.10 g/210 liters of breath. Nevertheless, glare recovery can be delayed for seconds at a BAC above 0.08 g/210 liters of breath, while peripheral vision and perception of objects in motion can deteriorate at even lower concentrations.

Effects on Skin. Alcohol is used on the skin as an antiseptic and topical rub. It imparts a cool feeling when rubbed on the skin due to dissipation of heat during evaporation. Absorption of alcohol through the skin is considered negligible. Alcohol that has been introduced into the blood causes the blood vessels of the skin to enlarge, allowing an increased amount of blood to circulate in the skin. This accounts for the "flushed face" characteristic of the habitual drinker.

Effects on Circulation. Low BAC levels have little effect on circulation except to enlarge the blood vessels of the skin, permitting an increase in the amount of blood circulating in the skin. No evidence exists that alcohol improves circulation. On the contrary, alcohol appears to impair circulation.

Effects on Kidneys. Alcohol is a mild diuretic increasing urine output. Moderate use of alcohol does not appear to cause any kidney damage.

Effects on Liver. Alcohol causes an accumulation of fat in the liver, a condition referred to as fatty liver. Cirrhosis of the liver, a fibrous scarring and shrinking of the liver, is often associated with alcohol consumption. However, the cause of cirrhosis is an indirect result of alcoholism due to poor diet and is found in less than 10% of chronic drinkers. Moderate use of alcohol does not appear to have a harmful effect on the liver as long as a healthy, nourishing diet is eaten.

Stages of Acute Alcoholic Influence/Intoxication

Stage of Alcoholic Influence	Clinical Signs/Symptoms
Sobriety	No apparent influence Behavior nearly normal by ordinary observation Slight changes detectable by special tests
Euphoria	Mild euphoria, sociability, talkativeness Increased self-confidence Decreased inhibitions Diminution of attention, judgement and control Loss of efficiency in finer performance tests
Excitement	Emotional instability, decreased inhibitions Loss of critical judgement Impairment of memory and comprehension Decreased sensory response, increased reaction time Some muscular incoordination
Confusion	Disorientation, mental confusion, dizziness Exaggerated emotional states (fear, anger, grief, etc.) Disturbance of sensation (diplopia, etc.) and of perception of color, form, motion, dimensions Decreased pain sense Impaired balance, muscular incoordination, staggering gait, slurred speech
Stupor	Apathy, general inertia, approaching paralysis Markedly decreased response to stimuli Marked muscular incoordination, inability to stand or walk Vomiting, incontinence of urine and feces Impaired consciousness, sleep or stupor
Coma	Complete unconsciousness, coma, anesthesia Depressed or abolished reflexes Subnormal temperature Incontinence of urine and feces Impairment of circulation and respiration Possible death
Death	Death from respiratory paralysis

Excerpted from: Kurt M. Dubowski, Ph. D., FAIC, Director, Department of Clinical Chemistry and Toxicology, University of Oklahoma, School of Medicine, Oklahoma City, Oklahoma, Member, Committee on Alcohol and Drugs, National Safety Council.

Table 4

Symptoms of Alcoholic Influence

Consumption of an alcohol may cause one or more of the symptoms listed below:

- ❖ Odor of alcoholic beverages on the breath
- ❖ Poor muscular coordination
- ❖ Swaying or unsteadiness
- ❖ Confusion
- ❖ Sleepiness
- ❖ Disorderly appearance
- ❖ Speech impairment, slurred and confused speech, "thick tongue"
- ❖ Dizziness
- ❖ Nausea
- ❖ Unusual actions, such as being very talkative
- ❖ Visual disorders, fixed stare, glassy eyes
- ❖ Flushed skin

This list is not all-inclusive nor does any one symptom or combination of symptoms mean that a person is intoxicated. Numerous illnesses/injuries can produce the same symptoms as alcoholic influence. The operator should, therefore, examine and question the subject carefully in order to ascertain whether or not medical attention is needed.

By alerting the subject's need for medical attention, chemical tests for breath alcohol can protect both law enforcement and the public. An abnormal behavior, coupled with a low BAC, may be indicative of illness and/or injury. Under these circumstances, the subject should receive appropriate medical attention. Conversely, an unusually high BAC also indicates the need for medical attention to prevent possible respiratory or cardiac failure.

Action with Other Drugs

Alcohol combined with other drugs can cause special problems. As stated previously, medical care should be obtained for any individual who has a low BAC but appears to be markedly under the influence.

Stimulants. Stimulants (amphetamines, caffeine, cocaine, etc.) do not counteract the depressing affect of alcohol. They may be used for temporary arousal in severe intoxication; however, their effect is brief.

Depressants. When alcohol is ingested with other depressant drugs, either non-narcotic depressants (tranquilizers, antihistamines, etc.) or narcotic depressants (heroin, morphine, etc.), the effects are usually additive. Prescribed doses of depressant drugs, when taken with alcohol, sometime result in an overdose and/or death because of respiratory failure.

Tolerance. People react differently to the consumption of alcohol. Some are better able to "hold" their liquor than others. Tolerance is the ability of a person to adapt to alcohol so that larger quantities are needed to produce a given effect. Most investigators have observed that tolerance to ethanol is limited to low BAC levels. Some factors that may influence tolerance are increased elimination and decreased penetration in the central nervous system.

NOTES

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